भारतीय विज्ञान संस्थान

Safety Manual

OFFICE OF LABORATORY SAFETY AND ENVIRONMENTAL HEALTH

SAFETY & EMERGENCY PROTOCOLS

This document lists the safety protocols that all laboratories in IISc need to follow. It also details emergency procedures.

Updated in January 2026

VERSION CHANGES

Version 2.00
Changes over Version 1.01
Updates in the SOP and rules, in line with new regulations.

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CHAPTER 1

Introduction

This manual aims to educate users about safety practices and emergency protocols in practice around the IISc Campus. While it covers many hazards, it cannot account for every possible situation. Users must exercise discretion and common sense at all times.

Repeated violations or wilful negligence of safety procedures may lead to strict disciplinary measures, including probation, fines, or, in severe cases, suspension of lab access.

1.1 Safety Principles

1.1.1 Define Standards



Fig 1.1 Safety signage to be displayed in the lab

Safe may mean different things to different people. To prevent confusion, IISc insists on established standards. The responsibility for defining safety protocols rests with the lab's Principal Investigator (PI).

Hazards should be clearly labeled so others can easily understand them, e.g., use warning notes and labels. Practices must be documented, not just communicated verbally.

The standards must comply with the IISc Safety Policy. All lab users in IISc must read and follow the IISc Safety Policy. The Safety Policy lays down the rights and responsibilities of each actor – student, staff, faculty, Department, and OLSEH. The standards must also comply with this Safety Manual.

1.1.2 Personal Responsibility



Fig 1.2 User referring to a chemical's MSDS

The ultimate responsibility for following the protocols rests with the experimenter. Supervisors cannot oversee the operations all the time. Users must be self-disciplined to follow the rules in letter and spirit, even if they appear burdensome or pointless. Be safe, not quick or easy.

Each individual must take responsibility in the event of an incident, for example, by triggering alarms to alert others or reporting unsafe conditions promptly. Hazardous behavior by any individual can jeopardise the safety of others. Safety is your responsibility.

The Institute works with every conceivable hazard. The government allows us to operate with considerable autonomy, trusting us to maintain the highest levels of safety. We must preserve this trust.

1.1.3 Structure, not Skill

No matter how careful, people make mistakes. An effective safety policy does not rely on people or skill but on systems to reduce the probability of accidents. Before beginning any project or process, think about all potential hazards – all the things that can go wrong. Focus on reducing the likelihood of accidents by intelligent precautions. Seek solutions that are "error-tolerant". "I will be careful with chemicals" is not an "idiot-proof" precaution; chemical-resistant gloves are.

Learn how to store, handle, and dispose of hazardous materials. Experiments should be conducted in designated areas with proper ventilation and appropriate safety accessories. Equipment should be well maintained with periodic inspections. The ultimate responsibility for funding and maintaining safety systems rests with the PI of the lab.



Fig 1.3 Proper use of PPE

1.1.4 Respond to Emergencies

Be prepared to respond quickly and effectively in an emergency. Be familiar with the work area, emergency protocol, e.g., location of emergency exits, eyewash stations, fire extinguishers, sinks, spill kits, and first-aid boxes. Just a few moments spent on training could save a life during an emergency. The ultimate responsibility for establishing training protocols, documenting them, and ensuring student participation rests with the PI of the lab.



Fig 1.4 Emergency exit door

1.2

Office of Laboratory Safety and Environmental Health

Office of Laboratory Safety and Environmental Health (OLSEH) polices safety in all labs at IISc. The OLSEH office has a team of experienced and trained EHS officers available to consult on safety issues. OLSEH has a repository of best practices. If you are unsure, contact them at safety.olseh@iisc.ac.in. All communication with OLSEH is confidential and shared only on a need-to-know basis.

Finally, OLSEH is the executive arm of the IISc Safety Committee. The OLSEH office has the right to conduct spot audits, seek information, regulate, and, in extreme cases, recommend disciplinary action. Please respond to any request from the OLSEH office.

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Bengaluru - 560012

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1.3

The Safety Network

All departments and centres have a designated Department Safety Champion. The updated list of Safety Champions is on the OLSEH website https://olseh.iisc.ac.in/safety-network/safety-champions/.

The Safety Champion is the primary contact point for any department-level safety-related concern. They are also looped in if the PI does not address lab-specific issues.

The Safety Committee is the apex body on all laboratory safety matters. If the OLSEH or Safety Champion cannot resolve your issue, please contact the Safety Committee at safetycommittee@iisc.ac.in.

If all fails, you can escalate issues to the Registrar, Deans, or the Director.

Safety is a collective responsibility. By following the principles in this manual and working together, we can sustain a strong culture of safety that safeguards the entire IISc community.

CHAPTER 2

General Safety

This section describes safety practices that are fundamental in any laboratory. Following these simple, "common sense" rules will save you from most laboratory hazards. These rules apply to all labs, even offices with just computers.

2.1

Lab In-Charges

Each lab will have a PI, typically a faculty member or permanent senior staff, responsible for establishing the protocols.

Each lab should also have a designated lab incharge, typically a senior student or staff member, responsible for enforcing safety protocols.

2.2

Definition of Specialised Labs

Specialised labs are defined as any labs having the following hazards. These labs have more hazards and deserve a higher burden of safety Equipment. Hence, the specialised labs will be audited more frequently.

Table 2.1 Criteria for identification of specialised laboratory

Category	Criteria
Laser	Class IV and non-visible lasers
Biological	Biosafety Level 3 (BSL-3) or higher
Electrical	Load > 100 kW or exposed voltage > 450 V
Radiological	Ionising radiation dosage > 20 mSv/year
Cryogens	More than 500 litres of liquid nitrogen, helium, or other cryogen
Gases	Any gas with an NFPA 704 rating of 3 or 4
Compressed Gas	Cumulative volume > 80 m^3 at > 200 kPa
Chemicals	As per OSHA 3844 classification (The table in annexure A)
Special Hazards	Home-built equipment involving combustion, high-temperature chemical reactions (> 500 °C), compression, or shockwaves - Labs with asphyxiation risks due to O_2 displacement or lack of passive ventilation

2.3

Safety Infrastructure

2.3.1 Provided by IISc

IISc will provide the following basic infrastructure in all labs. Any shortfall can be brought to the attention of OLSEH at *safety.olseh@iisc.ac.in*

Fire Safety	Alarms, hooters, and fire extinguishers in all labs. If mandated by NBC, sprinklers and hydrants also.
Emergency Plan	Documented emergency response plan with an Emergency Response Team run by the Security Office (ERT).
Signage	Exit signs, fire exit doors, and assembly points.
Hazardous Waste Collection	Hazardous waste collection service for segregated waste at regular intervals. Limited centralised storage capacity for waste chemicals.
Eyewash and Safety Shower	For hazardous chemicals: safety shower and eyewash station (ANSI Z358.1 standard; within 10 seconds or 55 feet from work area).
Transport Infrastructure	Ramp and/or service elevator for heavy goods, chemicals, or cryogenic liquids (on request per building).
Regulatory Compliance	Compliance with KSPCB, AERB, and other applicable regulatory requirements.
EHS Officers	Qualified EHS officers with domain knowledge. They conduct audits, send reports, and provide training.
Radioactive Safety	AERB-approved Radiation Safety Officer (RSO). Provision of TLD badges.

2.3.2 Maintained by PI or Department

Principal Investigators (PIs) or departments must maintain the following infrastructure, using project or departmental funds:

Orientation and SOPs	Documented safety orientation for new users; SOP for each hazardous equipment.
Lab Identification	Hazard sheet posted outside each lab.
Lifts and Transport	Working service lift (mandatory if: building ≥ 4 floors; or building ≥ 2 floors with compressed gas cylinders or hazardous chemicals).
Personal Protective Equipment (PPE)	PPE for all hazards in the lab as per regulations. See Chapter 3.
First Aid	First aid box (as per standard). Calcium gluconate if hydrofluoric acid is present.
Access Control	Controlled lab access (biometric or physical lock & key).
Emergency Power	Emergency light with battery backup or central UPS.
Electrical Safety	Circuit breakers with suitable ratings. Power disconnection must be allowed without entering the lab.
Chemical Storage	Hazardous chemicals must be segregated and stored in fire-rated chemical cabinets (≥ 30 minutes) or in a segregated area outside the main building.
Gas Storage and Alarms	Hazardous gases (NFPA > 2) must be stored in gas cabinets. Labs with hazardous gases must have interlinked gas alarms.
SCBA	Departments handling hazardous gases (NFPA > 2) must have at least one Self-Contained Breathing Apparatus (SCBA).
BSL-3 Labs	Hazard suits are stored outside the labs for rapid access by first responders during emergencies.

2.4

Safety Test

Safety policy requires that all lab users be trained in safety. Knowledge about general safety is mandatory for all, irrespective of the kind of work.

Special hazards like chemicals, compressed gas, lasers, bio-hazards, high-voltage, or radioactive materials need special training. OLSEH conducts an online test. Users are required to pass these tests.



Fig 2.1 General safety test is mandatory for all lab users

2.4.1 Eligibility and Requirement

a. The General Safety Test is mandatory for:
   - Students (UG, Masters, PhD)
   - Interns (short-term or long-term)
   - Technical staff (permanent or contract, if they use the lab)
   - Project staff (if they require lab access or work inside the lab)

b. Specialised chemical, biological, electrical, laser, radiation, and gas & cryo safety tests are mandatory for labs that house the respective hazards. For example, if you work in a lab with radioactive and biological hazards, you must take the bio and radiation safety test, even if you are not directly using the hazards.
   - The Dean has made the Biological Safety test mandatory for everyone in the Bio Division.

c. Exemptions: Faculty/PI, housekeeping staff, security personnel, administrative staff, and personal assistants/secretaries are not required to take the test.

2.4.2 Validity

The scorecard is valid for one year from the date of passing the exam. Users must pass the test again thereafter.

2.4.3 Passing marks:

21 out of 25 in each module

2.4.4 Verification:

a. A mail proof or a screenshot of the scorecard is sufficient for verification.

b. Automated emails with scorecards are sent only from the following addresses:
   - Aasindia-test-submit-2-donotreply@aon.com
   - safety.olseh@iisc.ac.in

2.4.5 Access Control:

Users without a valid pass certificate must not be allowed inside laboratories. The PI (or lab in-charge) is responsible for preventing unauthorised access.

2.4.6 Test Access:

The Online Safety Test can be accessed at https://olseh.iisc.ac.in/assessment/module.php

All newly joined students and staff should complete the test before being granted lab access. OLSEH monitors participation through internal data. Departments may contact OLSEH for assistance in case of technical or procedural difficulties.

2.5

Lab Audits

The IISc Safety Policy mandates regular laboratory audits to ensure a safe working environment and compliance with institutional, national, and international safety standards.



Fig 2.2 Safety officer interacting with lab users

2.5.1 Internal Audits:

a. Each PI or lab-in-charge is encouraged to conduct at least one audit annually, using the safety checklist provided in the Appendix.
b. Department Safety Champions should verify internal audits.

2.5.2 OLSEH Audits:

a. OLSEH EHS Officers will conduct periodic audits, typically every 6 months.
b. Specialised or high-risk labs (chemicals, biologicals, radiation, or high-voltage hazards) are audited more frequently, typically every 3 months.
c. The Safety Committee may change the schedule.
d. Unscheduled spot audits may be conducted.
e. OLSEH audits are not announced in advance.

a. Audit Process

- EHS Officers (internal auditors) inspect the lab against the audit checklist.
- Findings are documented and shared with the PI, Department Safety Champion, and Department Office.
- The PI must implement corrective measures within the timeline specified in the report.
- OLSEH may revisit to confirm compliance.

b. Consequences of Non-Compliance

- The OLSEH audit report is considered a “White” notice. Safety in-charges are expected to fix the issues promptly.
- Repeated violations or failure to act on the audit report will attract the more severe “Yellow” notice. Yellow notices are escalated to the Department Chair. Yellow notices have a time limit of seven days.
- Further violations or failure to act on the Yellow notice will invite a “Red” notice. Red notice is a formal order for the Department to shut down the lab. Users must not be allowed to work until the Red notice is lifted.
- In cases of severe negligence or imminent danger, OLSEH can directly issue Yellow or Red notices.

2.6

General Laboratory Practices

a. Safety orientation must be provided to all new lab users. The orientation program must be documented.
b. Please read the labels, material safety data sheets (MSDS), and user manuals before using unfamiliar materials or equipment. If in doubt, consult the safety in charge or OLSEH.
c. All known and anticipated hazards must be considered for planning experiments.
d. Users must be trained for any hazardous equipment or process.
e. Retraining of existing users is mandatory, especially if new hazards are introduced into a lab, e.g., new substances, processes, or equipment.
f. All hazardous equipment or processes must have a documented "Standard Operating Procedure" or SOP. Consult the Safety In-charges before deviating from SOP.
g. Only proper equipment, in good condition, should be used.
h. Don't do "jugaad". For example, anything that is not a ladder should not be used as a ladder, including boxes, chairs, cartons, shelves, chairs with wheels, etc.
i. Emergency equipment (e.g., fire extinguishers, emergency eyewash/shower units, etc.) should be unobstructed, clearly visible, and in working condition.
j. Spills must be attended to immediately and safely.
k. Eating, drinking, or applying cosmetics near hazards is not permitted. No food/drink should be allowed inside the lab.
l. Food and drinks must not be stored with hazardous materials. Refrigerators storing dangerous materials should have a label saying, "No food or drinks".
m. All laboratories must display the Laboratory Hazard Sheet (see Appendix) on the front door. To ensure the sheet is current, the laboratory in charge must sign and date it. The sheet should be posted at eye level on or near the door. The Hazard Sheet must be prepared according to the laboratory's safety plan. It must be reviewed and updated every six months. The sheet must be updated immediately if there are any changes in



Fig 2.3 Notice must be posted on the refrigerator at eye level



Fig 2.4 Always maintain a buddy system in the lab

the laboratory setup, processes, or hazards in the interim.

n. All labs should maintain a working landline near the door.

o. All labs must maintain a list of emergency contact numbers near the phone and one near the exit door at eye level. The emergency list should include cell phone numbers of the faculty, the lab in charge, and other regular lab users. The emergency list should also include the number of IISc health centres, campus security, local police, and fire stations.

p. Follow a "Buddy system." Never work alone in a lab, especially at night and on weekends. A "Buddy" is a fellow lab user who will be able to notice if you are in any distress. Friends on cell phones, in offices, or in hostels don't count.

2.6.1 Personal Care

a. Remove PPE before you leave the laboratory to prevent contamination.

b. You can retain the gloves and eyewear while transporting hazardous materials. However, don't use general-use elevators. Dirty gloves can contaminate buttons and other high-touch surfaces. Only service elevators or stairs can be used to transport hazardous materials.

c. Maintain personal cleanliness so that hazards don't affect you outside the lab. Always wash your hands, forearms, and face with soap and water after work, even if you wore PPE.

d. Confine long hair and loose clothing to keep them from catching fire, dipping into chemicals, or snagging in machinery.

e. Avoid wearing jewellery, which can reflect laser light or become entangled in equipment.

f. Avoid wristbands, rakhi, rings, wristwatches, and other ornaments. These may contaminate, react with chemicals, or snag in moving parts.

g. Keep fingernails short and avoid using nail polish, as chemicals may adhere to or react with them.

h. Avoid contact lenses near chemicals, biologicals, or fume hazards.

i. Do not apply cosmetics, lotions, or contact lenses inside the laboratory, as they may increase the risk of chemical absorption or injury.

j. Do not eat, drink, chew gum, or smoke in the laboratory to prevent accidental ingestion of hazardous substances.

k. Store personal items (bags, water bottles, mobile phones, etc.) outside the laboratory.

l. In case of contamination on clothing or skin, remove the contaminated clothing immediately and follow emergency washing procedures.

m. Use lab-designated footwear that fully covers the feet; avoid sandals, slippers, or open-toed shoes.

2.6.2 Good Housekeeping

a. Work areas must be uncluttered. Please clean them at the end of each workday, especially for hazardous materials and equipment.

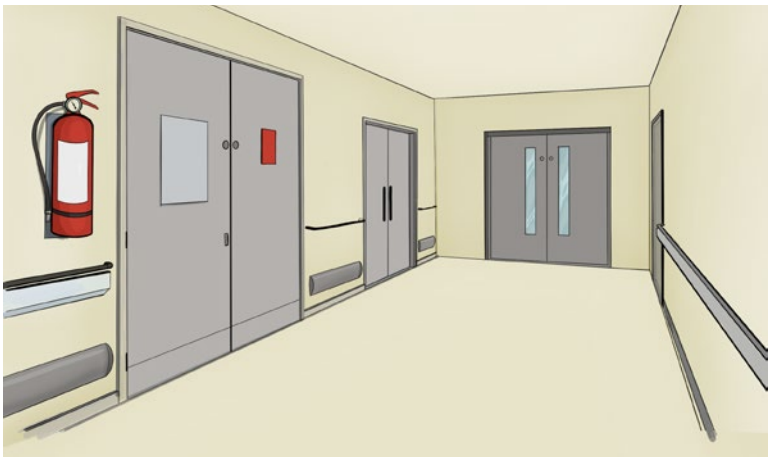


Fig 2.5 Keep passageways free of obstructions

b. Floors must be free from tripping, slipping, and falling hazards (e.g., cords, cables, wires, equipment, and tools).

c. Hallways and stairways are not storage areas. Corridors must be compliant with building codes.

d. Workbenches and shelves cannot be overloaded with equipment, chemicals, etc.

e. Labs need at least 2 feet of unobstructed space towards the emergency exits.

f. The housekeeping staff cannot handle any chemical-related spillage or hazardous materials.

g. The housekeeping staff are clearly instructed before cleaning the lab in any needed cases.

2.7

Guidelines for Safe Handling of Glassware and Tubing Connections

2.7.1 Hand Protection During Glassware Handling

a. When working with weak or cracked glass joints on a Schlenk line, thick cut-resistant gloves are advised to avoid cut injuries. This is in addition to the standard PPE necessary as per the chemical classification of the Schlenk Line

2.7.2 Safe Tubing Connection and Softening Practices

a. Excessive pushing, pulling, or twisting force on narrow glass necks, hose connections, or glass adapters must be avoided.
b. Rigid or semi-rigid tubing should be softened or eased before insertion or removal to reduce mechanical stress on glass components.
c. Softening and easing may be carried out by:
    - Gentle heating using a hot-air gun or heat blower
    - Use a hot-air gun only; open flames are strictly prohibited.
    - Maintain a distance of 10–15 cm, keeping the heat source continuously moving.
    - Heat only the junction area, not the entire tubing length.
    - Stop heating as soon as the tubing becomes slightly flexible.
    - Insert or remove immediately and allow to cool naturally.
    - Avoid overheating and never heat near flammable gases or solvents.
d. Other methods are
    - Dipping the tubing end in hot water, where compatible with the tubing material.
    - Use of a suitable compatible solvent (e.g., DCM), only when chemically safe and risk-assessed.
    - Light lubrication of the joint using a small amount of suitable lubricant (e.g., silicone grease) applied to the tubing end or glass joint. Excess lubricant must be avoided, particularly in vacuum, gas, or analytical systems
    - These measures significantly reduce the force required and minimise the risk of glass breakage and personal injury.



Fig 2.6 Safe handling of glassware

2.7.3 Inspection Before Operation

a. All glassware, especially customised or vacuum glass components, must be visually inspected before use.
b. Glassware showing cracks, chips, scratches, or stress marks must not be used and should be removed from service.

2.8

First Aid Kit

a. OLSEH guidelines for first aid kits are based on OSHA's standards.
b. First aid kits must be easily accessible. The kit handle should be no more than 48 inches from the ground.
c. The kit must be legibly marked as 'First-Aid Kit', in letters not less than 20 mm in height.
d. Minimum contents are:
   - Bandages and Wound Care
   - Assorted band-aids - Gauze pads (assorted sizes, at least 4×4 in) - Gauze roll (at least 2 inches wide) - Medical tape (for securing bandages)
   - Wound Cleaning and Disinfecting
   - Antiseptic wipes - Any safe disinfectant
   - Blister and Burn Care
   - Burn cream
   - General Medical
   - Medical gloves (latex or nitrile) - First aid manual - Scissors - Tweezers - Thermometer (oral or digital) - ORS (oral rehydration solution) - Mild soap
   - Eye wash solution - Eye drops
e. The first-aid kits must be designed per the lab's hazard profile. Mandatory extra items for the lab with specific hazards are:
   - Chemical Labs may need ointment with neutralising agents, e.g., calcium gluconate for HF.
   - Biological Lab may need antiseptic lotions/ creams.
f. Consider designating a person responsible for maintaining the first aid kit.
g. Regularly inspect the first aid kit and remove expired items.



Fig 2.7 First aid needs to be easily accessible

h. Restock the kit as needed.
i. Lab users must be trained in basic first aid. OLSEH conducts monthly trainings.
j. In case of a serious injury (secondary, direct, indirect, and chronic injury) or illness, always call the IISc Health Centre or seek immediate medical attention.

CHAPTER 3

Personal Protective Equipment (PPE)

Protective clothing and equipment (PPE) protect against laboratory hazards. In terms of cost-benefit ratio, PPE is your best defense against laboratory hazards. Lab users are expected to wear proper protective gear if they are working with any of the following hazards:

1. Chemical and Gas: Chemicals or gases with an NFPA rating of 1 or above.
2. Radiation: Lasers above Class II, exposed X-rays, or radioactive materials.
3. Electrical: High Voltage (above 50 volts AC or 120 volts DC) or high-power equipment (typically above 1 kilowatt).
4. Biological: Infectious molecules/ organisms, blood samples, etc.
5. Mechanical hazards, such as machining workshops with turning, milling, drilling equipment, power tools, spinning loads, equipment at high pressure, etc.
6. Cryogen: Low-temperature fluids.

3.1

Description of PPE

3.1.1 Eyes

a. Understand the difference between safety glasses, chemical splash goggles, and face shields. The first is for mechanical hazards, and the second is for splash/spill hazards that need 360-degree protection. The third is for extra safety while handling bigger hazards, such as large volumes of liquids, cryogens, and pressurized gases.
b. Eyes are easily injured, so in the vicinity of sharp objects, rapidly moving machines, hot material, or flying particles, safety glasses must be worn. It is strongly recommended that safety glasses be worn in all labs at all times.
c. Eyes are covered with capillaries, so they quickly absorb harmful chemicals. Splash goggles must be worn when there is a danger of splashing chemicals or cryogens.
d. Prescription spectacles do not provide protection. Please wear safety glasses/splash goggles over the prescription glasses.



Fig 3.1 Different types of glasses

3.1.2 Face & Head

a. When working with large amounts of chemicals, e.g., 4-litre bottles, or in the vicinity of explosive/implosive hazards, e.g., vacuum systems with glass jars, a face shield in addition to safety or splash goggles is recommended.
b. Safety helmets protect from falling objects, falls, and overhead bumps. Use safety helmets, hard hats, and bump caps if the lab has heavy overhead storage, overhead equipment that can fall, moving machinery, sharp edges, structures near or above head-height, and overhead electrical hazards.

3.1.3 Hands

a. Gloves prevent contact with toxic or biological agents, hot or extremely cold surfaces, corrosives, and sharp objects. Appropriate gloves need to be worn when handling hazardous materials or chemicals in a laboratory.
b. Safety gloves are available for all hazards. Select the correct glove for the hazard in question.
c. Ensure that there is no gap between the end of the lab coat sleeve and the glove.
d. Chemicals will eventually penetrate all materials. Change gloves periodically to minimize penetration.
e. Wash your hands after leaving the lab, even if you were wearing gloves. Long-term exposure to even minuscule amounts of toxins can have very adverse effects. Chronic exposure is very hard to diagnose or detect. Prevention is the only option.

3.1.4 Body & Feet

a. Cover your skin and wear full-length trousers, salwar, etc. No shorts are allowed while working in hazardous laboratories.
b. Avoid synthetic fabrics that may melt when exposed to heat or any chemicals.
c. Aprons or laboratory coats must be worn, especially when handling chemicals.
d. Always wear a flame-resistant, chemical-resistant lab coat or apron to protect against chemical splashes, heat, or biological agents.
e. Use chemical-resistant gowns or disposable coveralls when handling corrosives, infectious agents, or radioactive substances.
f. Wear hard-toe, good-fit shoes in labs to protect your feet. No slippers, sandals, or high heels. No one should be barefoot.
g. Separate footwear for the lab is useful to prevent dust and cross-contamination.
h. Wear shoes with slip-resistant soles on wet or chemical-spilled floors.
i. Wear reinforced safety shoes in areas with heavy equipment, glassware, or cryogenic liquids.
j. Remove protective clothing immediately after leaving the lab to avoid spreading contamination.



Fig 3.2 Different types of gloves

3.1.5 Masks & Breathing Apparatus

a. Masks & breathing apparatus protect laboratory users from toxic gases, chemical vapors, harmful dust, fumes, and oxygen-deficient atmospheres. Appropriate breathing apparatus must be used whenever there is a chance of inhaling hazardous chemicals, gases, or aerosols.

b. Masks & breathing apparatus are of various types with varying levels of protection, e.g., N95 masks, Air-Purifying Respirators (APRs), Powered Air-Purifying Respirators (PAPRs), Supplied-Air Respirators (SARs), and Self-Contained Breathing Apparatus (SCBA). To choose an appropriate respirator, follow the table below.

c. Inspect the breathing apparatus before using, ensure the correct fit and seal.

d. Air-Purifying Respirators (APRs), Powered Air-Purifying Respirators (PAPRs), Supplied-Air Respirators (SARs), and Self-Contained Breathing Apparatus (SCBA) need maintenance, like regular cleaning, inspection, timely replacement of filters or cylinders, correct storage, and record-keeping.

e. Supplied-Air Respirators (SARs) and Self-Contained Breathing Apparatus (SCBA) require training. Contact OLSEH.



Fig 3.3 Different types of masks and breathing apparatus

Table No. 3.1 Types of respirators

Type of Respirator	Protection Level	Typical Use Case / Hazard	Key Considerations
N95 Mask	Particulate filtration ≥95%	Dust, non-oil aerosols, mild airborne contaminants	Disposable; suitable for short-term exposure; does not protect against gases or oxygen-deficient environments
Air-Purifying Respirator (APR)	Depends on cartridge type (particulate, gas, vapor)	Solvent vapours, fumes, and dusts in the lab	Must select the correct cartridge; not suitable in oxygen-deficient atmospheres; limited duration based on cartridge capacity
Powered Air-Purifying Respirator (PAPR)	High-efficiency particulate + gas/vapor filters	High dust loads, chemical fume labs, and extended operations	A battery-powered fan provides airflow; it is more comfortable for long use, but it still requires a correct cartridge for specific hazards
Supplied-Air Respirator (SAR)	Continuous fresh air supply	Confined spaces, chemical handling with high vapor concentrations	Requires an air supply hose; safer in extended high-hazard conditions; mobility is limited by hose length
Self-Contained Breathing Apparatus (SCBA)	Independent air supply	Oxygen-deficient environments, highly toxic chemicals, and emergency response	Heavy, limited duration (usually 30–60 min); suitable for rescue or spill response; full PPE integration needed

3.1.6 Ears

a. Ear protection prevents hearing loss caused by continuous exposure to loud noise from centrifuges, compressors, vacuum pumps, alarms, high-frequency equipment, and accidental explosions.
b. Common ear protection includes disposable earplugs, reusable earplugs, earmuffs, and electronic noise-cancelling earmuffs used in high-noise laboratory areas. Disposable earplugs have an NRR of 25-35 dB and are suitable for noise levels of 85-95 dB(A). Reusable earplugs have an NRR of 20-30 dB, useful for continuous noise between 90-100 dB(A). Earmuffs provide an NRR of 25-35 dB and are recommended for high-noise areas like compressor or centrifuge rooms with 100-110 dB(A) sound levels. Electronic noise-cancelling earmuffs offer up to 20-30 dB protection and are ideal for variable or sudden loud noises above 95 dB(A). Choose ear protection based on noise level, comfort, duration of exposure, and compatibility with other required laboratory safety equipment.
c. Insert earplugs properly, ensure earmuffs form a tight seal, and avoid removing protection while inside noisy laboratory environments.

3.2

Minimum PPE

The “minimum” PPE must be worn at all times in all hazardous labs.

a. Eyes: Safety Glasses
b. Hands: Disposable thin-nitrile gloves. Avoid latex since it is permeable and can cause allergic reactions.
c. Body: Long pants or equivalent leg covering (no shorts). Synthetic clothing is not allowed when working with any fire hazards.
d. Close-toed shoes: Laboratory footwear should fully cover the feet. No sandals or flip-flops. The common practice of removing footwear outside the lab is not allowed. If dirt is a concern, please provide in-lab footwear (closed toe).
e. Tied hair: No loose long hair. All long beards and hair should be properly tied or covered.

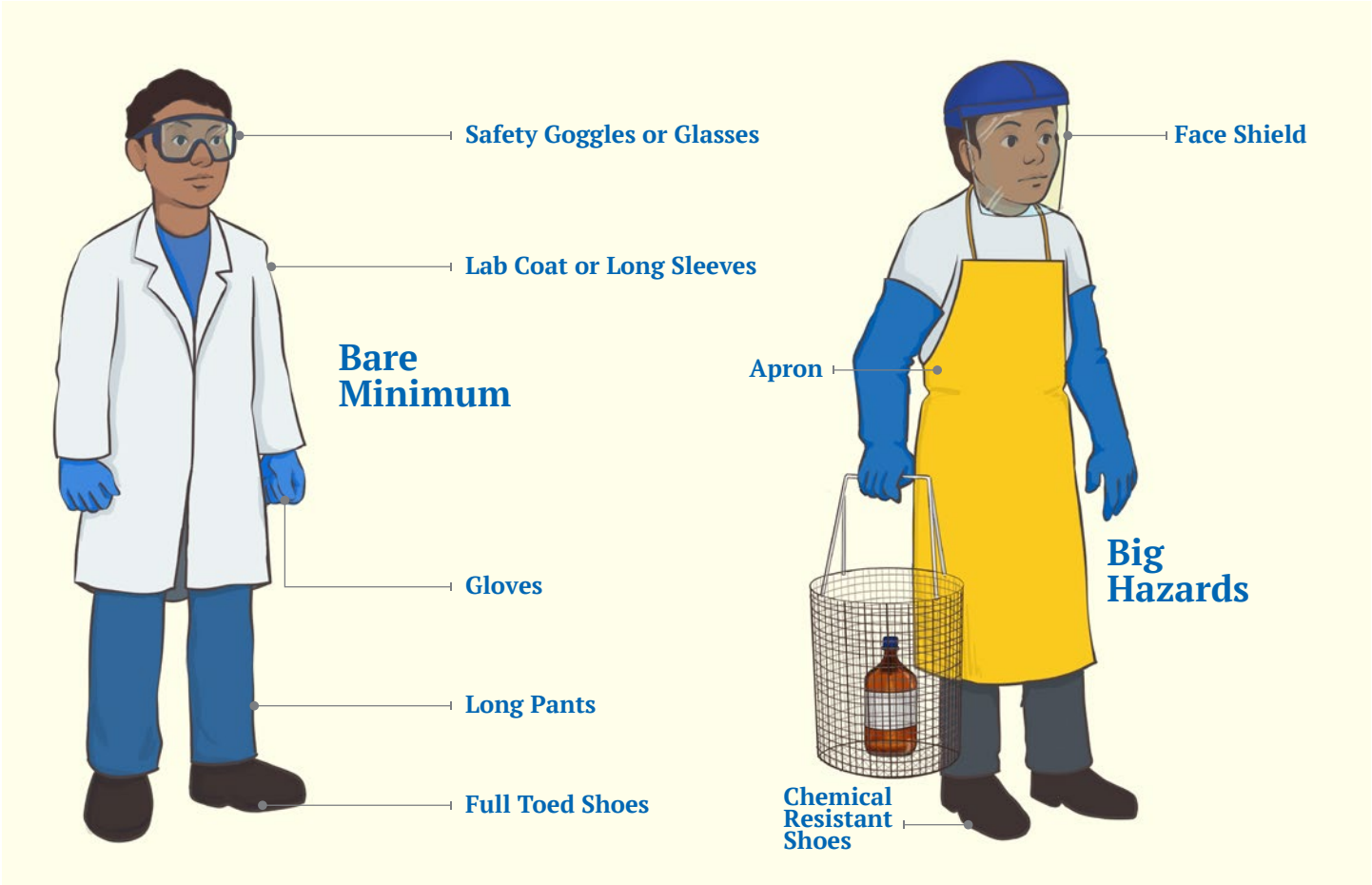


Fig 3.4 Minimum PPE vs. PPE for big hazards

3.3

Additional PPE

Additional PPE will be needed for specialized laboratories. A concise list of common use cases is given below. A larger table is provided in the Appendix. When in doubt, talk to an authority. *Always err on the side of more PPE!*

These are additional PPE, needed over all the above the minimum PPE.

a. Proper ventilation is directly linked to the effectiveness of PPE. Respirators, masks, and other protective gear can only provide adequate safety if background solvent or vapour levels are kept within safe limits, which requires fume hoods or local exhaust systems. In poorly ventilated labs, heat stress also discourages continuous use of gloves, coats, and face shields. Therefore, PPE requirements must be coupled with minimum ventilation standards: ensure adequate air changes per hour (at least 6–12 air changes per hour (ACH)), use fume hoods or portable extractors for chemical work, schedule hazardous tasks only in ventilated spaces, and suspend all chemical handling if ventilation fails. This ensures PPE functions as intended as the last line of defence, not the only one.

b. PPE is a consumable. Please replace it when it is worn out or torn.

c. Laboratories with hazardous chemicals must stock PPE appropriate for the type and quantity of chemical during both handling and storage.

d. The PPE must be within easy access of users.

3.3.1 General Hazards

Task	Potential Consequence	Additional PPE
Exposed to pressures >2 bar or a vacuum of <400 mm of Hg.	Skin damage Eye damage Implosion	Face: Face shield if no other implosion/ explosion barrier exists.
Working with high temperatures	Burns Fire Splash	Hands: Gloves suitable for the temperature. Body: Lab coat or apron suitable for the working temperature
Working with inert cryogens (He, N2, etc.)	Frostbite Eye damage Hypoxia in confined spaces	For ≤ 10Liters Body: Lab coat or apron Eyes: Safety goggles Hands: Inner disposable nitrile gloves + outer insulated cryogenic gloves
Working at elevation	Fall and subsequent injury	Height ≤ 3m Use ladders with a stable base. Ad hoc platforms, stools, and chairs are not allowed
High-speed machinery	Entangled hair. Flying scrap or particles	Tie long hair in a bun or use a hairnet. Hard-toed safety shoes Eyes: Safety glasses

3.3.2 Chemical Hazards

	Category	Maximum Limits in a quadrant	Hazard	Additional PPE (excluding minimum PPE)
1	Low hazard solids, e.g., zinc powder, Ca metal, magnesium hydroxide.	Particle size > 10 µm 	1. Eye damage 2. Skin exposure	1. Minimum PPE only 2. Fine particles of <10 µm are to be handled separately.
2	Moderate hazard solids, e.g., sulphur, magnesium & naphthalene.	Particle size > 10 µm 	1. Eye damage 2. Skin exposure 3. Fire	1. Eyes: Safety goggles 2. Body: Chemical-resistant apron or lab coat.
3	High hazard solids, e.g., sodium metal, potassium metal, & white phosphorus	Particle size > 10 µm 	1. Eye damage 2. Skin exposure 3. Explosible 4. Spontaneous fire	1. Eyes: Safety goggles 2. Face: Face shield 3. Hands: Chemical-resistant gloves (thick) as a second layer 4. Body: Chemical-resistant apron 5. Control: Use in a fume hood
4	Solids that are fine powders, like silica dust, carbon black, dry nanoparticles, & alumina polishing powder	Particle size < 10 µm 	1. Inhalation 2. Explosible	In addition to PPE specified for larger particle size, 1. Face: Suitable face mask or respirator 2. Control: Use in a fume hood only if the dust is explosive.
5	Low hazard liquids in small quantities, e.g., acetic acid & ethylene glycol.	Quantity < 100 ml 	1. Eye damage 2. Skin exposure	Minimum PPE only It is not applicable if the liquid is absorbed through the skin, is a long-term toxin (carcinogen, mutagen, teratogen), or is a nanoparticle solution.
6	Low hazard liquids, e.g., acetic acid & ethylene glycol.	Quantity > 100 ml 	1. Eye damage 2. Skin exposure 3. Splash	1. Eyes: Safety goggles 2. Hands: A second layer of thin nitrile gloves. 3. Body: Chemical-resistant apron or lab coat.
7	Moderate hazard liquids in small quantities, e.g., most alcohols (ethanol, isopropanol, methanol), acetone, xylene, chloroform, THF & DMF	Quantity < 100 ml 	1. Skin damage 2. Eye damage 3. Fire	1. Body: Chemical-resistant apron or lab coat. 2. Control: Ventilated area
8	Moderate hazard liquids, e.g., most alcohols (ethanol, isopropanol, methanol), acetone, xylene, chloroform, THF & DMF	100 ml < Quantity < 4 litres 	1. Skin damage 2. Eye damage 3. Fire, 4. Splash	1. Eyes: Safety goggles 2. Hands: A second layer of thin nitrile gloves is needed for permeating solvents (e.g., DMF, chloroform, THF) or prolonged contact. 3. Body: Chemical-resistant apron or lab coat. 4. Control: Use in a fume hood

3.3.2 Chemical Hazards (*continued*)

	Category	Maximum Limits in a quadrant	Hazard	Additional PPE (excluding minimum PPE)
9	High hazard liquids, e.g., sulphuric acid, nitric acid, alkali hydroxides, & formaldehyde	Quantity < 4 litres 	1. Eye damage 2. Skin damage 3. Splash 4. Inhalation	1. Eyes: Safety goggles 2. Hands: Chemical-resistant gloves (thick) as a second glove 3. Body: Chemical-resistant apron or lab coat 4. Control: Use in a fume hood. If a fume hood is not available, then a chemical-resistant apron is mandatory.
10	Any hazardous liquid in large quantities	Quantity > 4 litres 	1. Splash 2. Ingestion	In addition to the PPE specified for liquids 1. Eyes: Safety goggles 2. Face: Face shield with mask. Replace with a respirator if fumes are very noxious. 3. Hands: Chemical-resistant gloves (thick) as a second layer 4. Body: Chemical-resistant apron
11	Acutely toxic chemicals, e.g., hydrogen fluoride, hydrazine, hydrogen cyanide, chlorosulfonic acid, hydrogen sulphide at high concentration, phenol at high concentrations, nickel carbonyl & dimethylmercury		1. Eye damage 2. Skin penetration 3. Inhalation 4. Systemic toxicity 5. Lethal in small doses	Work inside a glove box OR 1. Eyes: Safety goggles 2. Face: Face shield. Suitable face mask if the material is noxious. 3. Hands: Two layers of appropriate gloves. Special gloves designed for that specific hazard are highly recommended. 4. Body: Chemical-resistant apron. 5. Control: Use in a well-ventilated fume hood or glove box with tight engineering control
12	Special toxin that is absorbed through the skin, a long-term toxin (carcinogen, mutagen, teratogen), or a nanoparticle solution. E.g., benzene, hexavalent Cr, ethidium bromide, DMSO, carbon tetrachloride, cadmium, lead, or mercury		1. Eye damage 2. Skin penetration 3. Inhalation 4. Systemic toxicity	Work inside a glove box OR 1. Eyes: Safety goggles 2. Hands: Two layers of appropriate resistant gloves 3. Body: Chemical-resistant apron 4. Control: Use in a well-ventilated fume hood or glove box with tight engineering control
13	Highly flammable chemicals, e.g., diethyl ether, acetaldehyde, Ethylene oxide, vinyl chloride & isopropyl ether		1. Explosible 2. Spontaneous fire 3. Flying debris	Talk to OLSEH. Need special permission and protocols. OLSEH inspection is mandatory.
14	Explosive chemicals, e.g., azides, hydrogen peroxide (>52%), picric acid, compressed ozone, fluorine gas, nitroglycerin, diazomethane & tetranitromethane		1. Explosible 2. Spontaneous fire 3. Flying debris	Talk to OLSEH. Need special permission and protocols. OLSEH inspection is mandatory.
15	Radioactive chemicals		1. Radiation 2. Systemic toxicity	Talk to OLSEH. Need AERB special permission and protocols. OLSEH inspection is mandatory.

3.3.3 Biohazards

	Level & Task	Potential Consequence	Additional PPE
1	BSL1 Handling clinical, animal, or biological samples that are not known to consistently cause disease in healthy adults, but can cause infection in immunocompromised adults, and pose minimal risk to personnel and the environment.	Accidental exposure or contamination to infectious material/ particles	1. Body: full sleeves, full-length lab coat or disposable gown/apron
2a	BSL 2 Handling or preserving animal or human specimens preserved in fixative (such as formalin or Paraformaldehyde solution)	1. Exposure to fixative is used to preserve the specimen. 2. If tissue is fixed, there is no longer exposure to infectious material.	1. Hand: An Impermeable glove that is chemically resistant to fixative. 2. Face: Face mask 3. Lab coat or disposable gown
2b	BSL 2 Working with radioactive human blood, body fluids, or bloodborne pathogens (BBP)	1. Exposure to infectious material 2. Cell damage 3. The potential spread of radioactive contaminants.	1. Face: Face mask (N95 or triple-layer mask, depending on the agent) + Face shield 2. Body: Lab coat or disposable gown 3. Appropriate radiological PPE according to the material being used.
2c	BSL 2 Manipulation of recombinant DNA, cell lines, venoms, and acute biological toxins., DNA, RNA, viruses, bacteria, or other organisms classified as Risk Group 2 and requiring Biosafety Cabinet class 2(A2, B1, or B2) to perform aerosol-generating procedures: Vortex, sonicate, pipette, tissue harvest.	Moderate potential for infection by injection (including needle prick), skin exposure, ingestion, or inhalation.	1. Face: Face mask (N95, N95 with respirators, or triple-layer mask, depending on the agent) 2. Body: Lab coat or Disposable gown

3.3.3 Biohazards (*continued*)

	Level & Task	Potential Consequence	Additional PPE
2d	BSL 2 Working with live animals, e.g., mice, rats, chicken eggs, rabbits, etc	1. Animal bites 2. Exposure to animal allergens. 3. Exposure to pathogens like Staphylococcus, Streptococcus, Candida, etc.	1. Eye: Safety goggles 2. Hands: Restraints or bite-resistant gloves 3. Face: N95 respirator. 4. Head: Hair bonnet 5. Body: full-cover lab coat or apron 6. Foot: Safety shoe (bite-resistant and water-resistant), shoe covers
3	BSL 2+[1] Working with infectious bacterial, viral, or fungal cultures. OR Handling human blood or bodily fluids, which have a higher risk than BSL2 but a lower risk than BSL3	1. Accidental infection or environmental contamination. 2. Direct exposure to bloodborne pathogens (e.g., HIV, Hepatitis), leading to infection.	1. Eye: Safety goggles 2. Hands: Nitrile gloves (double) 3. Face: N95 + other (triple-layered mask) 4. Head: Fluid-resistant head cover + Face shield. 5. Body: Full disposable coverall suit 6. Foot: Shoe cover
4	BSL 3 Manipulation of Risk Group 3 infectious materials (serious or potentially lethal diseases) requires Biosafety Level 3 (BSL-3) containment. E.g., pathogens like tuberculosis or some encephalitis viruses.	Serious or lethal potential for infection via injection, skin exposure, ingestion, or inhalation.	1. Eye: Safety goggles 2. Hands: Nitrile gloves (double) 3. Face: N95 or other triple-layered mask 4. Head: Fluid-resistant head cover + Face shield. 5. Body: Full disposable coveralls 6. Foot: Shoe cover 7. With animals, use bite-resistant/scratch-resistant gloves and body cover and water-resistant shoes.

3.3.4 Radiation Hazards

	Hazard	Potential Consequence	Additional PPE
1	Sealed sources with low dosage	Radiation-induced cell damage	1. TLD badges, if mandated by the RSO
2	Unsealed solid radioactive materials or waste.	1. Radiation-induced cell damage 2. Potential spread of radioactive material	1. Hands: Disposable nitrile or other impermeable gloves (double) 2. Face: N95 mask 3. Body: Lab coat or apron 4. TLD badges, if mandated by the RSO
3	Liquid radioactive material or waste in corrosive, flammable, or aqueous media OR Radioactive powders	1. Radiation-induced cell damage 2. Potential spread of radioactive material 3. Chemical exposure	1. Eyes: Safety goggles 2. Hands: Disposable nitrile or other impermeable gloves (double) 3. Face: N95 mask 4. Body: Lab coat or apron 5. TLD badges, if mandated by the RSO 6. Additional PPE is required for liquid media.
4	Open-beam X-rays that are not enclosed or interlocked inside the equipment	Radiation-induced cell damage	Talk to OLSEH. Special permission and protocols are required.

3.3.5 Lasers & Intense Light Sources

	Task	Potential Consequence	Additional PPE
1	Open-beam laser of Class 3 or above, in a setup that is not fully contained or interlocked.	1. Eye damage 2. Skin damage	1. Eye: Appropriate laser safety goggles/glasses with optical density based on individual beam parameters. 2. Skin: Fully covered arms and feet. Flame-resistant clothing. Avoid synthetics. 3. Avoid reflective jewellery. 4. Foot - Closed Toe Shoes
2	Troubleshooting or maintenance of a class 3 or above laser system in a way that defeats the interlock(s) or containment	1. Eye damage 2. Skin damage 3. Explosion of glass components	1. Eye: Appropriate laser safety goggles/glasses with optical density based on individual beam parameters. 2. Skin: Fully covered arms and feet. Flame-resistant clothing. Avoid synthetics. 3. Hands: Electrically insulated gloves 4. Avoid reflective jewellery. This is a specialised activity. The PPE above assumes the personnel are trained.
3	Working with intense light sources, infrared-emitting equipment, and UV sources (<400 nm)	1. Eye damage 2. Skin-burn	1. Eye: Appropriate laser safety goggles/glasses with optical density based on individual beam parameters. 2. Skin: Fully covered arms and feet. Flame-resistant clothing. Avoid synthetics. 3. Hand: Protective Gloves

3.3.6 Compressed Gas Cylinders & Cryogens

	Task	Potential Consequence	Additional PPE
1	Transport or handling of inert gas cylinders (NFPA 704 rating of <2 in all quadrants)	1. Loss of containment due to a fall or damage to the valve	1 Hand: Wear mechanically resistant gloves when handling cylinders. 2. Foot: Closed-toed shoes 3. Use a cylinder cart. No rolling.
2	Transport or handling of flammable gases with an NFPA 704 flammability rating of ≥3 & oxidizing gas cylinders	1. Loss of containment due to a fall or damage to the valve 2. Fire or explosion due to a sudden release	1. Skin: Flame-resistant antistatic safety clothing. 2. Hand: Wear mechanically resistant gloves when handling cylinders 3. Foot: Closed-toed shoes. 4. Use a cylinder cart. No rolling. 5. Use non-arcing tools 6. Discharge static electricity by touching grounded metal surface
3	Transport or handling of toxic gases with an NFPA 704 health rating of ≥3	1. Loss of containment due to a fall or damage to the valve 2. Release of inhalable toxins	1. Respiratory protection: Toxic gas mask or self-contained breathing apparatus 2. Hand: Wear mechanically resistant gloves when handling cylinders 3. Foot: Closed-toed shoes. 4. Use a cylinder cart. No rolling. 5. Use fixed or portable gas detectors to monitor the cylinder.
4	Transport or handling cryogenic liquids	1. Frost bite/ cold burn 2. Splash injury	1. Hand: Cryogenic gloves 2. Eye/ Face: Face shield/ Safety glass 3. Body: Cryogenic resistant apron/ lab coat 4. Foot: Closed toe shoes

3.3.7 Electrical Hazards

	Task	Potential Consequence	Additional PPE
1	Maintenance & repair of electrically powered equipment	1. Electrocution 2. Electric shock	1. Hands: Insulated electrical gloves. 2. Foot: Electrical safety shoes. 3. Work to be done by trained technicians ONLY.
2	Working with high voltage (> 400 V) or electric panel inspection or trouble shooting or near wet electrical environment	1. Electrocution 2. Arc flash 3. Burns 4. Electric shock	1. Body: Arc flash clothing. Switching suits are available from low-level to high-level protection. 2. Electrical-rated gloves and steel-toe cap boots with rubber are designed for protection against high voltage. 3. Electrical-rated safety helmet. 4. Remember to switch OFF the mains during work.
3	Working with battery charging systems or power supply units	1. Acid splash/ explosion 2. Electric shock	1. Hands: Chemical resistant gloves 2. Eye/ Face: Face shield/ Safety glass 3. Body: Lab coat/ protective clothing

CHAPTER 4

Chemical Safety

A wide variety of hazardous chemicals are used in IISc. Be vigilant!

4.1 Basics

a. The lab-in-charge must train all new users in chemical safety. We recommend yearly refreshers.
b. Become familiar with the location of fire extinguishers, spill kits, and first-aid boxes in your area. Familiarise yourself with their use. All laboratories with large amounts of chemicals must have access to a spill kit.
c. Before using a material, a user must find a safe way to store, handle, and dispose of the hazardous chemical.
d. Material Safety Data Sheets (MSDSs) must be reviewed for product-specific handling, storage, and disposal of information for all chemicals stored in a lab.
e. All researchers are responsible for educating themselves about the hazards of chemicals in their vicinity. The best way to do this is to read MSDS.
f. All labs are expected to maintain a folder of MSDSs for all chemicals in the lab. The folder must be stored in a visible location near the door. Online repositories are ok, provided they are searchable on demand.
g. Before finishing, ensure that the work areas are clean and that waste chemicals are properly disposed of. Any unattended chemical must be clearly labeled. There should also be a note with the user's name, phone number, and expected return time.
h. Maintain the manufacturer's label on chemical bottles. If the contents are moved to a secondary container, attach the IISc chemical label (see Appendix or download from the OLSEH website).
i. Chemicals must be used inside fume hoods.

Do not open chemical bottles outside of fume hoods. Details are below

j. Chemical waste should be segregated and labelled using the IISc Waste Label. See the Appendix or download from the OLSEH website.
k. Limit the amount of chemicals in the lab. Buy a moderate amount of chemicals that can be consumed soon. Don't let chemical waste pile up.
l. Don't mix incompatible chemicals. Specific compositions, like organic solvents and acids, are explosive.
m. Never add water to acid. Always add acid to water.
n. If inorganic fluorides are in the lab, a 2.5% calcium gluconate ointment should be in the first-aid box to treat burns.
o. Contact the trauma centre immediately if you think you have been exposed.
p. Proper Handling of Glassware: All reaction vessels must be securely clamped or supported properly; unstable placement on the bench/hood floor is strictly prohibited to prevent spills or splashes. Always use appropriately sized support for reaction flasks. Teflon rings are suitable for only up to 100 mL RB; larger flasks (≥250 mL) should be secured with proper clamps or properly sized rings, to prevent tipping and spills. Tissue paper may be placed inside the ring to provide additional stability for round-bottom flasks.



Fig 4.1 Lab user referring to a chemical's MSDS

4.2

Personal Protective Equipment (PPE)

Please refer to the PPE guideline in Chapter 3 for detailed instructions.

4.3

Fume Hoods & Exhaust

a. Chemicals produce hazardous fumes. The best way to handle this hazard is to evacuate the fumes using a fume hood connected to an exhaust. Here, "fume hood" refers to all exhausted enclosures, like chemical fume hoods, local exhaust ventilation (LEV), canopies, chemical glove boxes, ventilated storage cabinets, exhausted dustbins, etc.
b. These guidelines do NOT apply to gas cabinets. Refer to Gas Safety for gas cabinets.

4.3.1 Fume Hoods

a. Fume hoods are engineering controls that reduce exposure to hazardous vapours. They consist of a semi-enclosed area connected to an exhaust to maintain a minimum air flow. This dynamic barrier drastically reduces the fumes the user is exposed to.
b. Fume hoods are primarily used for handling odorous or hazardous materials with minimal exposure. A secondary objective is to protect the user from spills by partially enclosing the work area.

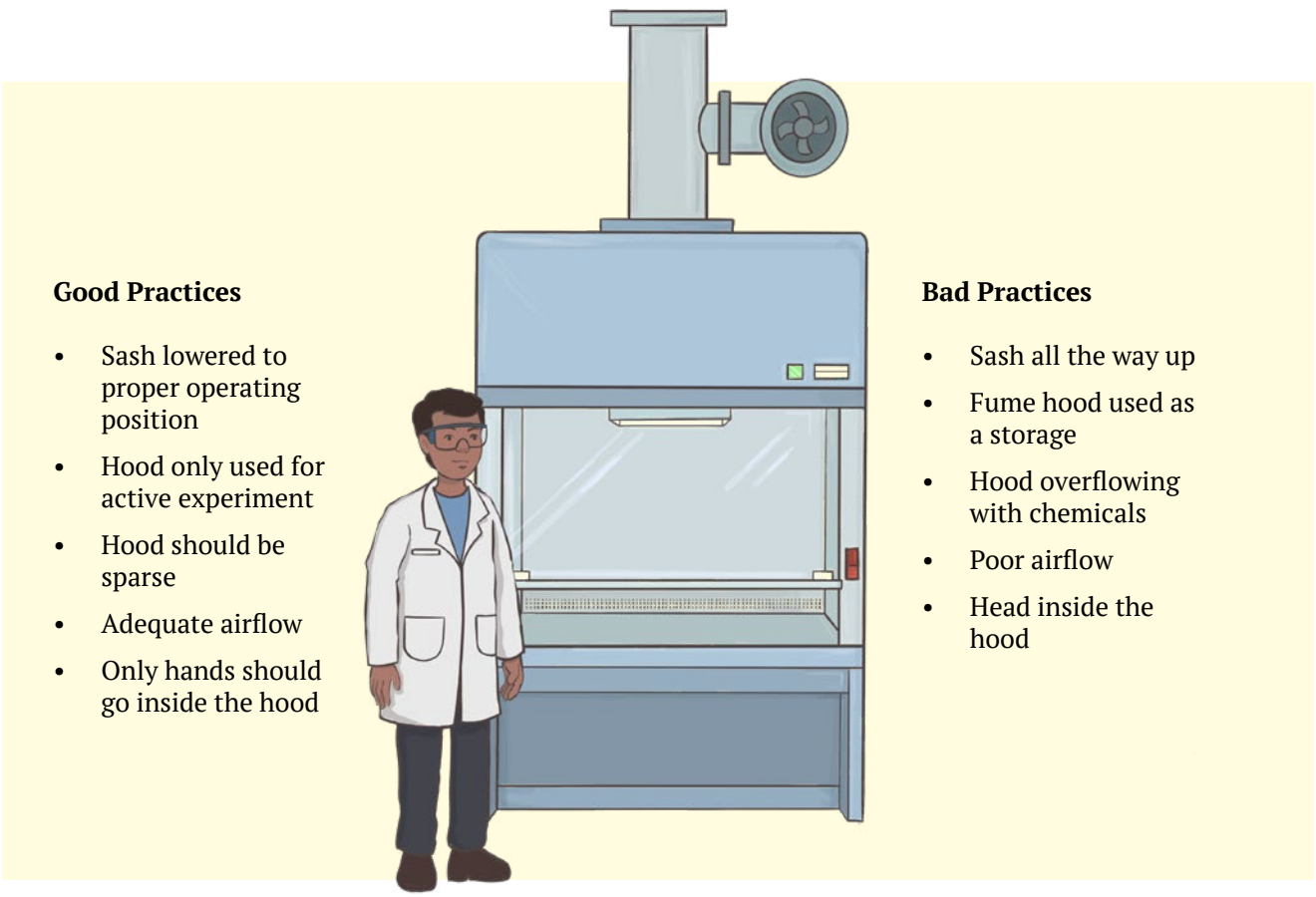


Fig 4.2 Good vs. bad fume hood practices

c. The hood is connected to an exhaust blower with ducts and dampers. Dampers and blowers need to be serviced at least once a year.
d. Any experiments generating air contaminants at or above the permissible exposure limit (refer to MSDS) should be conducted inside the fume hood.

4.3.2 Flow in a Fume Hood

a. The flow of a fluid is measured in terms of linear flow velocity, usually denoted in feet/min or meters/hour. To calculate the exhaust capacity, you must multiply the flow of velocity by the hood area (in m2 or ft2) to calculate the cubic flow rate, usually denoted in cubic-feet/min (CFM) or cubic-meter/hour (CMH).
b. The hoods require a minimum face velocity of 30 m/min (i.e., 100 linear feet per minute) at normal working conditions. Hoods for highly toxic materials (NFPA>2 in health or explosive category) require higher face velocities (up to 45 m/min or 150 linear feet/min). Fume hoods should never operate beyond 150 ft/min to prevent turbulence that could expose the user to fumes.
c. Hoods have a sash that can be moved to change the air flow. The "normal working height" of 100 LFM must be clearly marked. The minimum (minus 50 LFM) and maximum (plus 50 LFM) positions must also be marked. Mechanical stops should be installed to prevent the sash from exceeding the minimum and maximum positions.
d. The fume hood is unusable if the flow is less than 75 LFM. Unusable hoods must be marked with a "DANGER HOOD IS NOT WORKING! DO NOT USE!" tag.
e. The face velocity of hoods must be measured using an anemometer.
f. Ideally, the anemometer must be permanently installed in hoods. Users are expected to check the flow before starting work in a hood.
g. If an anemometer is not installed, the lab safety-in-charge must measure the flow in the hood monthly using a portable anemometer. These readings must be recorded in a log accessible to all users and OLSEH officers.
h. EHS Officer or an authorized third party must assess the operation of hoods once a year.

4.3.3 Operations

a. Assess the hazards before beginning work on a new material.
b. Use hoods with an adequate face velocity.
c. The user should always remain outside the hood. Never put your head inside a hood to check on an experiment.
d. Place the hood sash at the working height. Never work with the sash in a fully open position. Place the sash at the lowest position to conserve power when not used.
e. On hoods where sashes open horizontally, position one of the doors to act as a shield in the event of an accident in the hood.
f. Avoid storing chemicals in the fume hood's working area. This not only clutters the workplace but also disturbs the flow.
g. Label all your samples appropriately before storing them in the fume hood; it will be important for all the fume hood users to be aware of the contents inside the hood.
h. Keep your work at least 6 inches from the hood sash's plane of movement.
i. Clear at least 50% of the work area, so the flow is not disturbed.
j. Any equipment that needs to remain in hoods should be elevated on racks or feet to allow airflow underneath.
k. Do not block the baffles at the back of the hood. These allow for the proper exhausting of contaminants from the hood.
l. Fume hoods shall not be near busy walkways or air diffusers.
m. Minimize foot traffic in front of the hood.
n. If a reaction becomes uncontrollable, turn off the heat, stop adding reagents, alert any nearby lab personnel, and keep the chemical fume hood fully closed until the temperature goes down.



Fig 4.3 Lab user working in fume hood

o. A fume hood is only the first line of defense against accidents. The hood users should wear safety goggles, lab coats, and appropriate chemical gloves while working around the fume hood.
p. Empty bottles can be dried in the hoods. However, do not use the hood exhaust to evaporate large amounts of volatile materials. Use normal chemical waste disposal channels only.

4.3.4 Construction

a. OLSEH recommends commercial hoods. Home-built hoods are deprecated.
b. Hoods must be made of a material appropriate for the hazard. Wood and particle board are not allowed.
c. The hoods must have corrosion-proof fittings.
d. Hoods must have an inbuilt light.
e. The hood sash should have shatterproof or reinforced see-through glass/plexiglass.
f. Chemical cupboards should be so designed that there is a strong upward draught even when the shutter is open, and there is no chance of fumes entering the laboratory. For extremely poisonous vapours, it is advisable to have an air inlet at the bottom for continuous air flow and evacuation.
g. The hood shouldn't be too deep to allow easy access to the fittings inside, and controls for the service connections should be placed outside.
h. The exterior/ interior walls, work surfaces, and duct material of a fume hood must be chosen based on the intended usage of the hood, e.g., PVC/FRP ducting is often used for corrosives.
i. The exhaust blower should be compatible with the fumes created in the hood. It must be sized appropriately (see the section on flow 4.3.2).
j. Ductless fume hoods that recirculate the exhaust back into the laboratory do not replace fume hoods, as they do not provide sufficient protection from hazardous vapours. Ductless hoods are deprecated, even if they have active filters designed for specific chemicals.
k. Similarly, elephant trunk systems or canopy hoods are not substitutes for fume hoods, as they only provide partial capture and do not ensure full protection. If used, they must be placed within a few inches (typically 6–12 inches) of the source and are suitable only for nuisance vapors, moderate heat, or over columns/fractions—not for toxic or highly volatile chemicals.

4.4

Transport, Storage, and Use of Chemicals

a. Don't carry chemical bottles in your hands. Transport chemicals in bottle carriers, carts, buckets, etc.
b. Store the four classes of chemicals separately, i.e., acids, bases, solvents, and oxidizers. If there is an issue of space, solvents and bases can be stored together, and acids and peroxides can be stored together. However, chemicals that can react violently or emit hazardous fumes when mixed should not be stored near each other. For example, oxidizers and flammables must never be stored together.
c. Some chemicals have expiry dates. Chemicals stored beyond their shelf life are dangerous. For example, ether, tetrahydrofuran, & dioxane form explosive peroxides, which can detonate while opening the bottle. All such chemicals must be labeled with the expiration date before being stored.
d. Flammable materials should be stored in chemical cabinets with a 30-minute fire rating and exhaust. Small quantities (< 100 ml) can be left on benches, but only during use.
e. Corrosive materials should be stored in plastic or epoxy-coated steel cabinets. The cabinets must be connected to an exhaust. Corrosive chemicals can also be stored in a drawer under the fume hoods. If metal cabinets are used, the secondary containment must be plastic. Metal cabinets must be replaced if there are signs of corrosion.
f. All cabinets must be labeled by chemical class (e.g., flammable liquids, acids, oxidizers) to ensure chemicals are suitably segregated.
g. Acids, bases, and oxidizers must be stored inside cabinets with secondary containment (to contain the spill in case the first container ruptures). Corrosion-resistant plastic trays are a low-cost option for secondary containment.
h. Large bottles and bottles containing toxic, flammable, or corrosive liquids should be stored on shelves below eye level (maximum 5 feet). Corrosive materials can cause severe tissue damage and are particularly injurious to the eye.
i. Volatile or unstable materials may be stored in



Fig 4.4 A Transporting chemical safely using a cart, not by hand



Fig 4.4B No food or drink on benches or in refrigerators used for chemical storage

a flammable-rated refrigerator only in properly sealed containers. Never store flammable solvents (ether, benzene) in the fridge in open containers (beakers).

j. Food or drink should never be stored in a laboratory refrigerator or freezer. A "No food/drink" notice is required on all laboratory refrigerators.

k. Corrosive chemicals must not be stored in incompatible containers. For example, hydrofluoric acid is incompatible with glass. Inorganic hydroxides are best stored in polyethylene containers.

l. Never leave an unlabelled bottle of "something" after finishing work. Everything should be labeled with the Chemical label (See Appendix or OLSEH website).

m. All high-hazard chemicals must be used in the fume hoods only. Hazard categories are defined in the PPE section.

n. Glass syringes with metal Luer lock tips (1–50 mL) with longer needles offer a safer alternative to disposable plastic syringes, particularly for hazardous chemicals.

4.4.1 Volatile Solvents

a. Highly volatile solvents, like Acetone and alcohols, are often flammable with a low flash point. They ignite even at low temperatures.

b. Flammable solvents must only be transported in chemical buckets. A spill of a gallon bottle of Acetone could cause a catastrophic fire or explosion.

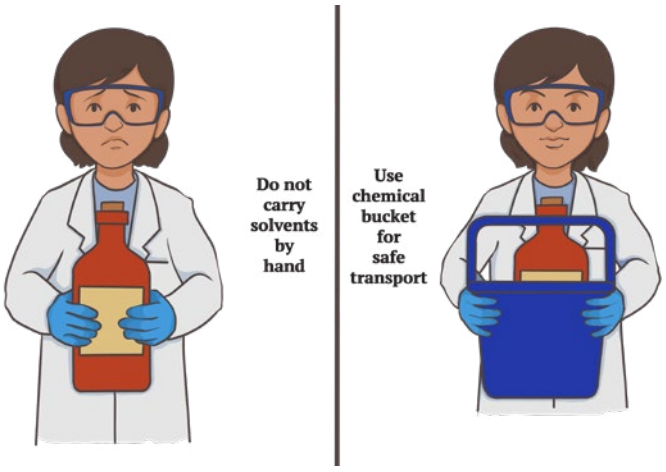


Fig 4.5 Chemical bottle transport

c. Highly volatile solvents should only be used inside fume hoods.

d. Never use volatile solvents near a hot plate. The hot plates can ignite spilled solvent. The resulting fire could easily be drawn into the exhaust ducts with catastrophic consequences.

e. Solvents can react explosively with oxidizing agents, e.g., peroxides and nitric acid. Never mix them.

f. Spilled solvents should be contained immediately with chemical spill kits. Seek help as required.

4.4.2 Chlorinated Solvents

a. Chlorinated solvents are particularly hazardous, causing cancer and organ damage. Examples are chlorobenzene, trichloroethylene, and methylene chloride.

b. As with most solvents, they can be readily absorbed through the skin.

c. Chlorinated solvent waste should be segregated as a distinct category. Do not dispose of them as non-halogenated "solvents".

4.4.3 Peroxides

a. Peroxides are oxidizers. Be careful when mixing peroxides with other materials. Peroxides are incompatible with organic solvents.

b. Peroxides can also be unstable and explode.

c. The class of organic peroxides is even more dangerous. Please read the MSDS before use.

d. Some solvents, like ethers, Tetrahydrofuran (THF), and dioxane, form peroxide when exposed to oxygen and light. Before use, check for peroxides by using KI or peroxide test strips. Dispose of solvents with peroxides. Don't attempt to purify them.

4.4.4 Handling Large Quantities

a. These guidelines apply anytime you work with more than 10 liters of chemicals. The situation occurs frequently during waste or bulk solvent collection.

b. Do not lift heavy drums: Do not lift heavy containers. Use a siphoning pump or a drum tap. If impractical, place the receiving container at a lower



Fig 4.6 Transferring solvent safely

level and pour liquid from the source drum down.

c. Proper Ventilation: Always perform solvent transfers in a well-ventilated area, preferably within a fume hood or using local exhaust ventilation.
d. Secondary Containment: Place the receiving container within a chemical-resistant spill tray.
e. Size the Funnel: Do not use small funnels when transferring liquids from heavy drums. Hold the funnel slightly above the container to prevent pressure buildup.
f. Wear PPE: Please refer to the PPE section for the appropriate PPE for handling large amounts of liquids.

4.4.5 Distillation

a. Distillation is a common laboratory procedure that presents a fire and explosion hazard.
b. All distillation setups should be inside a fume hood
c. Minimize the amount of chemicals in a batch.
d. Ensure all wiring is intact to avoid electrical shock and sparks. Wires should not hang outside the fume hood.
e. Violent boiling, or "Bumping", can cause solvent splashing or rapid vaporization. Use boiling chips or a magnetic stirrer to prevent bumping.
f. Ensure glassware is oven-dried and inspect for any defects, such as star cracks.
g. Fill the round-bottom flask with no more than two-thirds of the solvent.
h. Seal all joints with joint clips and Teflon.
i. Agents like sodium metal, LAH, CaH_2, and P_2O_5 dry solvents before distillation. Before adding these reactive agents in bulk, always test the moisture level in 1-2 ml of solvent. Ethers like THF and DME require pre-drying with activated molecular sieves.
j. OLSEH recommends the use of high-quality anhydrous solvents instead of drying agents. If drying is required, identify the proper drying agent. For example, drying dichloromethane with sodium generates explosive carbenes.
k. Cut metallic sodium inside the fume hood while wearing the required PPE.
l. Ensure a dry-powder fire extinguisher is nearby and accessible before working with sodium.
m. Use purified argon or nitrogen as inert gases.
n. Clearly label the still with the solvent and drying agent (e.g., THF/Na, DCM/CaH_2) on a note outside the hood.
o. Some solvents, like ethers, THF, and dioxane, form peroxides when exposed to air and light. Before distillation, check for peroxides using KI or peroxide test strips. Dispose of peroxide-contaminated solvents. Never distill a peroxide-contaminated liquid.
p. Standard protocols are available for hexane, THF, DME, Toluene, or DCM solvents.
q. Start cold water flow through the condenser only after the apparatus is fully assembled under inert gas flow.
r. The distillation setup must always be supervised. Don't leave the lab without shutting down the setup. Do not run the still overnight on "simmer" mode.
s. The distillation flask should never dry out. Use an overflow connector or monitor the setup continuously to prevent accidental drying.

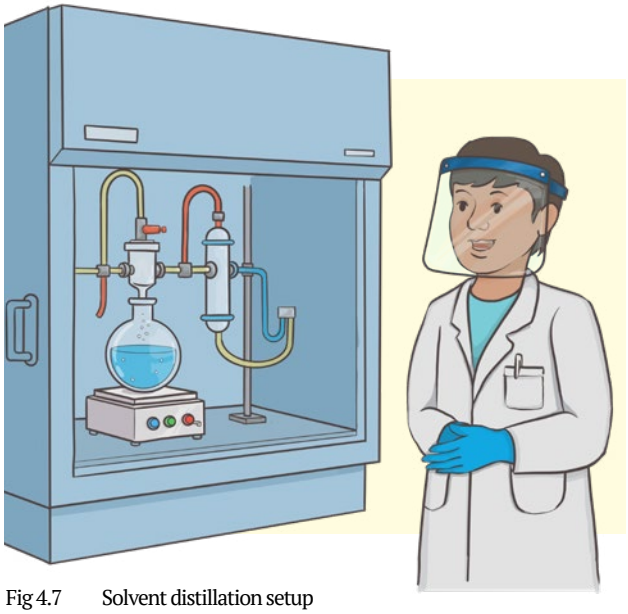


Fig 4.7 Solvent distillation setup

t. Keep the fume hood sash fully closed during operation.
u. The residual solvent containing sodium or other drying agents should be carefully quenched by small amounts of propanol, followed by absolute methanol, until the sodium is destroyed.
v. Allow the still and heating mantle to cool to room temperature before handling.

4.4.6 Inhalation Hazards

a. Airborne substances, like gases, vapors, dust, fumes, or mists, pose an inhalation hazard.
b. Solids that can aerosolize should only be used with masks or ventilators, e.g., dust, small particles (< 10 µm), dry nanoparticles, etc.
c. Volatile, fuming, or mist-generating liquids should only be used in ventilated areas.
d. Some equipment produces airborne hazards in fumes, dust, or mist. e.g., physical vapour deposition systems (sputtering, evaporation, etc.); sand-blasters; grinders, low-melting point metals; solids that sublime at low temperatures; etc. These hazards are compounded if the same equipment handles toxic materials. Care must be taken to reduce exposure to this equipment or toxic materials. Use gas masks and respirators.
e. Gases are another common source of inhalation hazard. Please follow the guidelines on gas safety.
f. Some gases, like H_2S, occur naturally and can be tolerated in small amounts. Hence, there is a tendency to discount their severity. This is a mistake. Always refer to the MSDS. When such information is not available, err on the side of caution.



Fig 4.8 Sources of inhalation hazards

4.4.7 Chemical Inventory and Storage Management

a. Ensure that the chemical inventory includes the following information for all corrosive, moisture-sensitive, and reactive chemicals:
   - Date of receipt
   - Date of first opening
   - Approximate quantity remaining

b. Old or unused chemicals (older than 2–3 years) must be periodically reviewed. If any chemical shows physical changes such as discoloration, pressure buildup, or haze formation, its use should be discontinued immediately, and the material should be disposed of.

4.4.8 Proper Use of Chemical Fume Hood

a. Users must strictly follow OLSEH fume hood usage guidelines.
b. Training should emphasize avoiding work with the sash fully open under any circumstances.
c. The hood sash must be operated at the recommended working height to ensure user protection and airflow efficiency:
   - For vertical sashes: Keep the sash below chin level while working.
   - For horizontal sashes: At least one sash panel must fully cover the user's body, allowing only the hands to reach inside for handling bottles or reaction setups.
d. Each hood should have clear signage/label indicating the adequate sash height, as users frequently forget to adjust it correctly during operation.

4.4.9 Standard Operating Procedure (SOP) for Hazardous Chemical Handling

a. Ensure that each lab maintains a written SOP for handling hazardous, reactive, moisture-sensitive, and corrosive chemicals, covering their storage, transfer, and disposal procedures.
b. The SOP must clearly specify safe handling techniques, including Hood Operation:
c. Always work inside the hood, not at the edge. The bottle or reaction setup should be placed at least 6 inches inside the hood from the front edge. Working near the edge can cause fume escape, as suction is weaker there.
d. Secondary Containment: Always place the chemical bottle on a secondary containment tray (plastic or Teflon) inside the hood to catch spills or drips—never directly on the metal/hard surface.

4.4.10 Bottle Handling:

a. Hold the bottle firmly by its base, not by the neck.
b. Slightly tilt the bottle away from your face within the hood enclosure, keeping it roughly at arm's length.
c. Do not lift the bottle upward while tilting—keep its bottom supported on the tray or hood surface.
d. Loosen the cap slowly, allowing any built-up pressure to release gradually so that escaping vapours are captured by the hood airflow. This practice helps prevent sudden fume bursts toward the user.

4.4.11 Stench Chemicals & Lachrymators

a. Stench chemicals are not necessarily toxic, but create an overwhelmingly noxious smell even in minuscule quantities, such as butyric acid, valeric acid, selenides, telluride compounds, thiols, etc.
b. Lachrymators cause severe eye, nose, and respiratory tract irritation, leading to tears ("lachryma" = tears in Latin), sometimes even in minute quantities. Examples are thionyl chloride ($SOCl_2$), acrolein, benzyl chloride, phosgene ($COCl_2$), and dimethyl sulfate.
c. Researchers must inform all lab users, the lab in charge, & PI before using stench chemicals or lachrymators.
d. Store the stench chemicals & lachrymators in tightly sealed containers with teflon tape.
e. Rubber septa are not a good way to contain these chemicals, because they permeate rubber.
f. Only use the minimum necessary quantity.
g. Always work inside a fume hood or glove box.
h. Keep the fume hood sash as low as possible.

i. Use Schlenk lines or a bleach trap for stench chemicals.
j. Use Schlenk lines or a glove box for lachrymators. Double containment is mandatory.
k. Transfer liquids using a syringe or cannula only. Never pour. Decontaminate and discard any pipettes or micropipettes.
l. Do not use a rotary evaporator to concentrate reaction solutions. Use a vacuum with a cold trap.
m. Abate the exhaust chemicals, even if fume hoods or glove boxes are used. Exhausted vapours can re-enter through air intakes or wind.
n. Stench chemicals can be abated by activated carbon or oxidizing scrubbers like bleach or $KMnO_4$.
o. Alkaline scrubbers can abate lachrymators.
p. Waste from the abatement systems is a chemical hazard. Handle it with PPE and dispose of it as chemical waste.
q. Clean used labware by rinsing and submerging it in bleach for up to 24 hours.
r. Any solid waste (e.g., gloves, paper towels, septa) should be put in a sealed (zip-lock) bag. Take the bag to the chemical waste shed.
s. For minor spills of stench chemicals or lachrymators: wear PPE, confine spill with absorbent pads, clean surfaces with 3% H_2O_2 and $NaHCO_3$. Avoid bleach as it forms hydrochloric acid. For lachrymators, you will need a respirator or SCBA. Take the waste to the chemical waste shed.

4.4.12 Pyrophorics

a. Pyrophorics ignite spontaneously in air (no heating or sparks needed). Examples are metal alkyls like trimethylaluminium, t-butyllithium, and Grignard reagents; hydrides like NaH, KH, $LiAlH_4$, silanes and arsine; and spent catalysts like Raney nickel & palladium on carbon.
b. Researchers must inform all lab users, the lab in charge, & PI before using pyrophorics.
c. The PI must sign off on a documented (hardcopy) standard operating procedure (SOP).
d. OLSEH approval is mandatory. Must be informed in advance & invited to conduct a safety audit. OLSEH will check SOP.
e. Always wear appropriate PPE. See the section on PPE
f. Glass bottles of pyrophoric reagents should not be handled or stored unprotected. The metal can that ships with each bottle should be retained as a protective container for transportation and storage.
g. Read online about safe handling practices for pyrophorics, especially if working outside a glove box. Two resources are:
   - "Methods for the Safe Storage, Handling, and Disposal of Pyrophoric Liquids and Solids in the Laboratory" Journal of Chemical Health & Safety 2011, January/February 18(1), 5–10.
   - Aldrich Technical Bulletin AL-134.
h. Pyrophorics must be handled inside a high-flow fume hood or glove box. Secondary containment, like a glove bag or Schlenk lines, is mandatory.
i. Never pour pyrophorics. Use syringes with long needles to transfer small quantities. Quantities beyond 50 ml must use the cannula (double-ended needle) transfer technique. Syringes should never exceed 50% capacity. Volumes beyond 50% are hazardous because there is a risk of the plunger leaving the barrel, spilling the contents.
j. Pyrophorics must be abated using catalytic burn boxes with wet scrubbers.
k. Plans for the safe destruction or proper disposal of unused/unreacted material. Discuss the plan with OLSEH during the approval process.
l. All used labware should be cleaned immediately after use, flushed with the solvent, dismantled, and cleaned with appropriate solutions.
m. In the event of a spill, powdered lime should be used to smother and cover the spill completely. A container of powdered lime should be kept within arm's reach when working with pyrophoric materials.
n. Pyrophoric spills may ignite. To quench, you may need a Class D fire extinguisher. Never use water or CO_2, as they might react with pyrophorics. Plan to have one in advance.

4.4.13 Explosives

a. When exposed to shock, pressure, or high temperature, an explosive rapidly releases pressure, gas, and heat. Some chemicals can become unstable or potentially explosive over time due to contamination from air, water, or metals, or if they dry out. Examples include Picric acid & TNT.
b. Researchers must inform all lab users, the lab in charge, & PI before using explosive chemicals.
c. PI must sign off on a documented (hardcopy) standard operating procedure.
d. OLSEH approval is mandatory. Must be informed in advance & invited to conduct a safety audit. OLSEH will check SOP.
e. Conduct experiments in a fume hood or glove box with a safety shield. We need double containment.
f. Remove unnecessary equipment and chemicals from the work area.
g. Notify others in the lab about the experiment, hazards, and timing.
h. Use non-sparking tools when handling explosive chemicals.
i. Always wear appropriate PPE. See the section on PPE
j. Always use high-purity solvents to minimize hazards associated with impurities.
k. Date the chemical containers when received & opened. Explosives have strict expiry dates.
l. Explosive chemicals must be regularly monitored. Users must maintain a logbook where the condition is tracked. Containers should not deteriorate. Compounds like picric acid must remain moist. There should be no crystalline growth inside or outside the container. There should be no discoloration.
m. Explosives must never be scraped with a spatula, as the friction may initiate an explosion.
n. Avoid concentrating explosives. Don't let them crystallize. Materials that should remain "wet" must not dry.
o. Avoid overcooling to prevent the dangerous buildup of unreacted reagents, which could lead to a violent reaction upon warming.
p. Standard OLSEH waste disposal does not account for explosives. Discuss with OLSEH to define an SOP.

4.5

Waste Segregation & Disposal

a. Chemical waste is prima facie hazardous and must be segregated and disposed of according to the pollution control board rules. This is a regulatory requirement with legal consequences. Any sanction will be institute-wide. A mistake from one can affect many. We also have a moral obligation to maintain the environment.
b. The PI must enforce a documented procedure to segregate and dispose of all waste generated in the lab.
c. In general, waste must be stored in the same container it was sold in (glass, plastic, or metal). As much as possible, avoid glass containers as they shatter easily.
d. A small amount of waste can be collected in the labs. At least once a month, lab incharges must collect all the waste and bring it to the OLSEH waste collection shed or pickup point.
e. OLSEH provides free pickup for most types of segregated chemical waste.
f. Please fill out the disposal form shared on the intranet (campus bulletin) in advance and drop the sealed waste at the designated pickup points on the announced dates. Details are on the OLSEH website. OLSEH also sends a reminder on the Campus Bulletin.
g. Only labeled and segregated waste will be collected. Follow the segregation and labeling rules. No mystery chemicals, please.



Fig 4.9 Colour-coded chemical waste bins and biowaste pickup

4.5.1 Categories of Waste

a. The KSPCB and the waste vendor regulate categories. So, expect the specifics to evolve with time.

b. Solvent waste is the generic category for non-toxic liquid waste. Solvent waste must be segregated into the following.
   - Halogenated (DCM, Chloroform, CCl_4, etc.)
   - Non-halogenated (THF, ethyl acetate, hexane, Acetone, methanol, etc.)
   - Aqueous – Acidic (pH<4)
   - Aqueous – Basic (pH>10)

c. Solid waste is the generic category for non-toxic solid waste. Solid waste must be segregated into the following:
   - Sharps waste (Needles, blades, broken glass, shards, etc.).
   - Non-toxic "polymeric" waste (nitrile gloves, wipes, plastics, Gel ice packs, etc.).
   - Non-toxic "oxide" solid waste (Ceramics, semiconducting wafers, clay, silica, empty vials/ centrifuge, etc.

d. Toxic waste is a generic category for solid or liquid waste that is a mutagenic, carcinogenic, or environmental toxin. Toxic waste must be segregated into the following.
   - Toxic transition metals like Cd and Cr.
   - Toxic metal complexes of Cr, Co, Cu, Ru, Os, etc.
   - Compounds with heavy metals like Hg and Pb.
   - Cyanides

e. Empty Chemical bottles from used chemicals can be separately disposed of. OLSEH picks up all types of plastic, metal, and glass bottles of up to 25-liter capacity.

f. Unknown Chemicals: Unsegregated chemicals are VERY expensive to dispose of because they must be assayed first. The PI or department bears the cost of disposing of segregated chemicals. Unknown chemicals can be any of the following:
   - Mixed wastes without proper composition,
   - Chemicals with faded or missing labels.
   - Abandoned chemicals with a label but no responsible owner, e.g., bottles from closed labs.

g. Waste oil can be from any source, like pumps, diesel generators, etc. It can be used or unused.

Table 4.1 Hazardous waste disposal schedule

Waste Type	Disposal Frequency
Bio-hazardous waste	Weekly
Liquid Waste	Monthly
Solid Waste	Monthly
Toxic Waste	Monthly
Waste oil	Bi yearly
Radioactive waste	Monthly
Unknown Chemicals	Every 2 Months
Empty Chemical Bottles	Every 2 Months
Old/Empty Compressed Gas Cylinders	Once every 6 Months
Lithium/Small Consumer Batteries	Once every 6 Months
Lead Acid Batteries	Once every 6 Months
Toxic and Flammable Gas Cylinders	On Request from PI/ Department

4.5.2 Segregation SOP

a. Chemical waste must be segregated. When in doubt, segregate. It is a very low-effort activity that saves a lot of headaches later.
b. An acid + solvent mixture can spontaneously ignite. Never store/leave a solvent + acid mixture in the lab unattended. If you do happen to make such a solution, segregate it and take it outside of the building to the waste shed.
c. Acidic waste with fluoride ions must be collected separately in plastic containers, eg, dilute hydrofluoric acid, ammonium fluoride, and buffered-oxide etch.
d. Environmental toxins like Cd, Cr, or Pb must be collected separately.
e. Acid waste that does not contain metallic toxins or fluoride and has a pH<4 must be separately collected in plastic containers. IISc does not allow individuals to neutralize acids.
f. Acid waste that does not contain metallic toxins or fluoride and has a pH>4 can be disposed of in the drain with copious amounts of water.
g. Acids + oxidizers react and evolve gas. So unattended acids+oxidizer mixtures present an explosion hazard. Fresh acids+oxidizer mixtures must be collected separately and kept inside the fume hood for a day, to let the gases escape.
h. Nitric acid should be treated as an acid+oxidizer.
i. Base+oxidizer mixtures also evolve gases. So unattended base+oxidizer mixtures present an explosion hazard. Fresh base+oxidizer mixtures must be collected separately and kept inside the fume hood for 1 day, to let the gases escape.
j. Solvents + oxidizer mixture can spontaneously ignite. Never store/leave a solvent + oxidizer mixture in the lab unattended. If you do happen to make such a solution, segregate it and take it outside of the building to the waste shed.
k. Solvents must be separately collected in plastic containers, eg, benzene, ether, ethyl acetate, Acetone, alcohols, hydrocarbons, etc.
l. Basic waste with a pH > 10 must be separately collected in a plastic container. IISc does not allow individuals to neutralize bases. If they do not have any oxidizer, bases can be stored with solvents.
m. Non-toxic basic waste with a pH<10 can be disposed of in the drain with copious amounts of water.

4.5.3 Waste Sheds

a. The State and Central Pollution Control Board regulates and audits chemical waste sheds.
b. OLSEH maintains two centralized waste storage sheds near the SERC and the New Chemical Science Building. They are open to all IISc users on all workdays.
c. The department can build its own storage areas, following the guidelines. OLSEH will audit these facilities.
d. The IISc chemical shed operates from Monday to Friday.
e. A lab attendant registers the type of wastes re-

ceived, their quantity, the department/lab, and the contact person.

f. The waste must be labeled with the label and should not leak.
g. The sheds don't accept bio-wastes, empty chemical bottles, or unknown chemicals.
h. Flammable, ignitable, reactive, & incompatible wastes should be stored separately.
i. Adequate firefighting systems should be provided for the storage shed.
j. The loading area of the waste shed should allow easy movement of waste containers.
k. A truck must be able to access the loading area of the waste shed.
l. The storage and handling should have an extra emergency exit.
m. Proper records concerning the type of waste received, characteristics, and the location of the waste stored in the facility must be maintained.
n. Only persons authorized to enter and trained in hazardous waste handling procedures should have access to the storage site.
o. Loading & unloading of wastes in storage sheds should only be done by a well-trained staff under the supervision of an experienced staff member.
p. Smoking shall be prohibited in and around the storage areas.
q. Good housekeeping needs to be maintained around the storage areas.
r. Waste should be adequately protected from direct exposure to sunlight, and adequate ventilation should be provided.

4.5.4 Waste Containers

a. Waste should be placed in compatible containers with secure screw-on tops and labeled with the "IISc Waste Label" (See Appendix).
b. Drums containing waste stored in the storage area should be adequately labeled, indicating the type, quantity, characteristics, source, date of storage, etc.

4.5.5 Spill Control

a. The storage areas should be inspected daily for leaks or deterioration.
b. In case of spills/leaks, use professional spill kits. Storage areas should store adequate spill kits. The waste shed should have spill kits to handle the chemicals stored inside.
c. Waste shed should have secondary containment, to prevent percolation to the soil & groundwater. The storage area should be provided with a concrete or steel floor.

4.5.6 Waste Pickup

a. OLSEH collects laboratory waste through registered vendors on a monthly, Bi-monthly, and bi-yearly schedule in the following categories.
b. The vendor vehicle picks up waste from designated pickup points. OLSEH announces dates in advance. Email reminders are sent to Campus Bulletin.
c. Chemical waste will NOT be collected from individual labs separately. The waste must come to the pickup point on the pickup day.
d. Fill out the waste disposal form in advance. Forms are on the OLSEH website.
e. The waste should be labeled with chemical waste labels. Labels can be downloaded from the website.



Fig 4.10 Waste Can with label

f. Waste bottles with missing details will not be picked up. OLSEH expects all fields, like the name of the departments/lab, contact person, name, mobile number, type of solvent, etc., to be mentioned clearly.
g. Please ensure that the waste containers are tightly sealed.
h. Leave some headspace to avoid pressure buildup during transport.
i. Use 04-litre bottles or 25-litre jerry cans to store liquid waste.
j. Unless chemical compatibility or safety mandates otherwise, use only plastic bottles.
k. Fill all non-sharp solid waste in high-quality, thick garbage bags that don't tear easily. The filled bag must be tied off so the waste cannot leak or spill.
l. Do not place solid waste directly into cardboard boxes, as they can get damaged and leak. However, small glass bottles (toxic liquid, solid, or empty) must be packed in sturdy cartons for safe transport and not disposed of loosely.
m. Sharps (needles, syringes, pipettes, broken glass) must be collected in puncture-proof solid chemical waste containers.
n. Don't open or pour the contents into a new bottle for an unknown chemical. Leave it as it is.
o. Error on the side of caution. If you feel that transporting a container is hazardous, don't move it. If you are unclear about how to dispose of something, don't guess. Contact OLSEH at safety.olseh@iisc.ac.in.
p. Empty chemical containers can contain residual amounts of chemicals. All chemical containers, liquid or solid, must be rinsed three times.
q. The first rinse should be collected as chemical waste and disposed appropriately; the second and third rinses can drain.
r. Dry the empty container by letting it sit in a well-ventilated area. Use a fume hood (if you can access one) or find an isolated area far from the public.
s. Use proper PPE during the rinsing of chemical bottles or containers.
t. Deface the empty container label. The chemical name should be crossed out or blacked out before being discarded.
u. Any broken glass containers must be placed in a rigid box marked as "broken glass."
v. For radioactive and bio waste guidelines, refer to the relevant chapters.

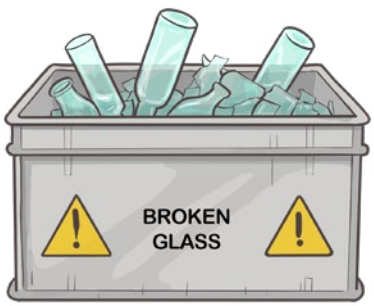


Fig 4.11 Broken glass

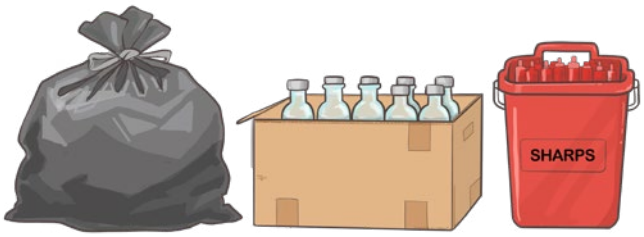


Fig 4.12 Packing solid waste

4.6

Special Hazard: Hydrofluoric Acid

a. Hydrogen Fluoride (HF) is a commonly used hazardous chemical. Concentrated solutions are 40 to 70% by weight in water. HF is also used as an anhydrous gas.
b. HF is used to etch glass and semiconductors, digest minerals and soils, and remove oxide coatings from stainless steel ("pickling").

4.6.1 Hazards that make it Special

a. HF is highly corrosive and toxic.
b. Inhalation: HF fumes have a pungent, irritating, penetrating odour. HF can be smelled at 0.04 ppm (a relatively safe level). Still, one should not rely on odour for safety. The Threshold Limit Value (the concentration to which most workers can be exposed daily for a working lifetime without adverse effects) is three ppm. The threshold where HF is "immediately dangerous to life and health" is 30 ppm.
c. Skin Exposure: Skin exposure can lead to severe burns, tissue destruction and death (necrosis), and systemic toxicity. Pain associated with hydrofluoric acid exposure is usually described as deep, burning, or throbbing and is disproportionate to apparent skin involvement.
d. Long-term Exposure: Long-term or chronic exposure to HF may result in fluorosis, a syndrome characterised by weight loss, bone brittleness, anaemia, and general ill health.
e. Eye Exposure: Exposure of the eyes to HF may result in blindness or permanent eye damage.
f. Ingestion: Ingestion of hydrofluoric acid is rare and hence poorly reported. Based on evidence, ingestion will probably cause esophageal burns, systemic toxicity, and cardiac arrhythmias (similar to skin exposure).

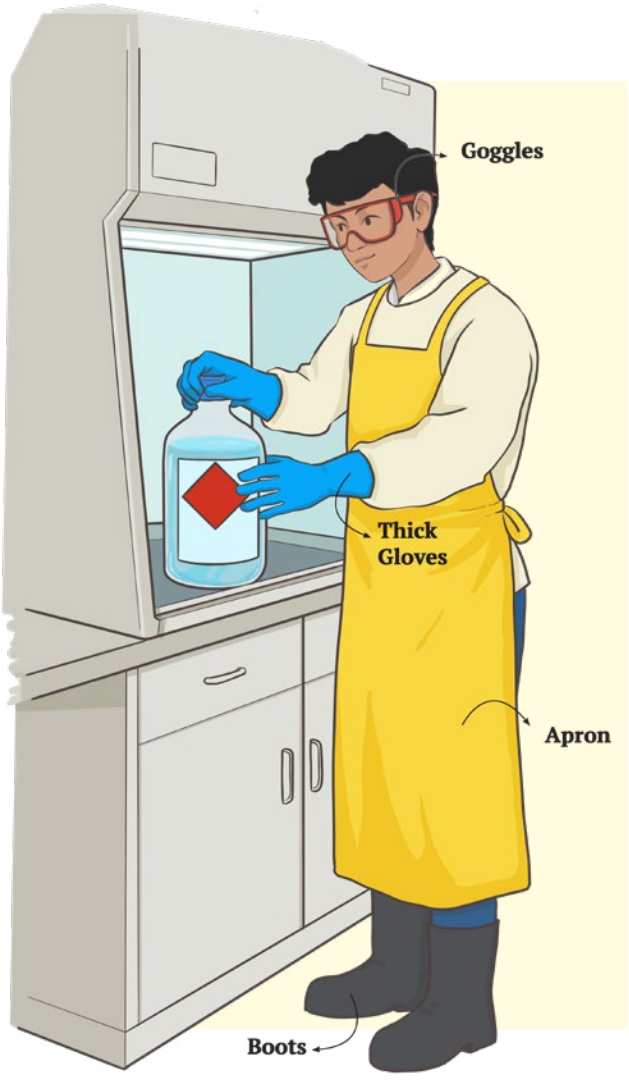


Fig 4.13 Required PPE for handling hydrofluoric acid

4.6.2 Best Practices

a. Wear proper PPE (see below).
b. Be prepared for an emergency. Pre-planning is essential before beginning any HF work. Know the location of eyewash, safety showers, and calcium gluconate.

4.6.3 Training

a. HF-specific training is mandatory for all users in a lab that stores HF.
b. The training will cover hazards, controls, PPE, handling, storage, disposal, and emergency response.
c. Each lab must have at least one person trained in spill control.

4.6.4 Engineering Controls

a. Aqueous or gas HF must be used only inside a properly functioning fume hood.
b. HF corrodes metals and glass, damaging general-purpose hoods. Special hoods made with polypropylene must be used.
c. PPE is mandatory for any concentration of HF solution above 0.001%.
d. Make sure the PPE is in good condition. When in doubt, replace HF PPE.
e. Always use chemical splash goggles when handling HF. Safety glasses, even those with side shields, do not provide adequate eye protection.
f. Thick nitrile gloves are mandatory. Six-mil-thick nitrile gloves resist around 45 minutes to concentrated HF. These gloves can be used multiple times, provided they are washed after each use. The gloves should be discarded at the first sign of deterioration.
g. Users must always wear a second layer of thin nitrile gloves underneath the thick ones.
h. HF-resistant aprons are mandatory. Aprons or lab coats made with natural fibers are inadequate. The aprons should be full-sleeved. Separately worn sleeves are ok. The apron must be below the knees.
i. Fully closed plastic shoes are mandatory.

4.6.5 Storage

a. Store HF in properly labeled, compatible polyethylene, polypropylene, or Teflon containers. Never store in a metal or glass container or a silicone-based bottle.
b. Periodically check the condition of the container since plastic containers can get brittle over time.
c. Store HF containers in a ventilated chemical cabinet, separate from incompatible chemicals like bases, metals, and organic compounds.
d. The cabinet must have secondary containment, such as a tray.

4.6.6 Emergency Response

a. Skin Exposure: Wash the exposed area with flowing water for 5 minutes. Don't use stagnant water, like dipping your fingers in a beaker of water. Remove contaminated gloves and use a fresh pair of gloves. Apply copious amounts of calcium gluconate gel using a fresh pair of gloves. Ungloved hands should not be used to apply calcium gluconate on HF-contaminated parts. Seek medical attention while you continue the application of calcium gluconate.
b. Eye Exposure: Immediately irrigate eyes at the eyewash for at least 15 minutes with a copious amount of water. Keep eyelids apart and away from eyeballs. Do not apply calcium gluconate gel to the eyes. Seek prompt medical attention.
c. Inhalation: Move the exposed person to fresh air. Seek prompt medical attention.
d. Ingestion (Swallowing): Do not induce vomiting. Drink large amounts of water to dilute the acid. If available, several glasses of milk or milk of magnesia. Seek prompt medical attention. Do not give any fluids to an unconscious victim.

4.6.7 Spill Clean Up

a. Small spills can be cleaned by a user in proper PPE.
b. Spill kits for HF clean-up are available. Only use kits specified for HF spills, typically the absorbent is soda ash, sodium bicarbonate, lime, etc.

c. Don't use spill kits that contain sand because HF reacts with silica to produce silicon tetrafluoride, a toxic gas.

4.6.8 Disposal

a. Cylinders of anhydrous HF should be returned to the vendor. If you have old cylinders that you cannot return, contact the OLSEH at safety.olseh@iisc.ac.in
b. Hydrofluoric acid solutions should not be thrown down in the drain, even if the solution is neutralised. Bottle, label, and dispose of the HF through regular chemical disposal.
c. Extreme care must be taken when disposing of large quantities or high concentrations.
d. Chemical suppliers will also sell HF mixtures with various non-aqueous solvents such as HF-pyridine or HF-alcohol mixtures. It is not appropriate to neutralize these mixtures. Bottle, label, and dispose of the HF through regular chemical disposal.

CHAPTER 5

Biological Safety

The Indian Institute of Science (IISc), Bangalore, is committed to maintaining the highest standards of safety in teaching, research, and innovation. This Biosafety Manual aims to protect students, researchers, staff, the environment, and the surrounding community from potential biological risks arising from laboratory activities.

The manual outlines key aspects of biosafety, including risk assessment, classification of biological agents, biosafety levels (BSL), use of personal protective equipment (PPE), waste management, emergency response, and incident reporting. It also aligns with national regulatory requirements and best practices to ensure safe and responsible conduct of research.

All personnel working in laboratories involving biological materials are required to understand and adhere to the guidelines provided in this manual.

5.1

Good Practices

Table 5.1 BSL-1, BSL-2 and BSL-3 Safety Practices

	BSL-1 (Low Risk)	BSL-2 (Moderate Risk)	BSL-3 (High Risk, Aerosol Transmission)
Live culture handling	1. Standard microbiological practices 2. No eating/ drinking in the lab 3. Wash hands 4. Surface decontamination is mandatory 5. Always use pipetting aids. Never mouth pipette.	BSL-1 practices, and additionally: 1. Only trained personnel can handle BSL2 cultures. 2. Lab access must be limited. 3. Documented SOP is required for the storage and transport of cultures 4. Documented SOP is required for instruments, waste, sharps, and bio spills. 5. Infectious materials should be in a durable, leak-proof primary container. The primary container is in a durable, leak-proof secondary container for transport within the facility (e.g., to an incubator or another lab bench). 6. The secondary container should be decontaminated if there's suspicion of contamination. 7. Properly label all containers. 8. Use biosafety cabinets (BSCs) for potentially aerosolized pathogens. 9. Ensure proper functioning of BSCs and other safety equipment. 10. Minimize splashes and aerosols.	BSL-2 practices and additionally: 1. Controlled access with two sets of self-closing doors, often with an anteroom. 2. All personnel must undergo comprehensive training in BSL-3 practices, procedures, emergency response, and the specific risks associated with the agents being handled. 3. ALL open manipulations of BSL-3 cultures, and any procedure with these cultures that could generate aerosols or splashes, must be performed inside a certified Class II or Class III Biosafety Cabinet. 4. Work within the designated safe zone of the BSC, avoiding disruption of the air curtain by rapid arm movements or blocking the grilles. 5. All culture vessels (flasks, plates, tubes, cryovials) must be robust, leak-proof, and sealed during handling and storage outside of the BSC (e.g., when moving to an incubator or centrifuge). 6. If using screw-cap tubes, ensure caps are tightly secured. For plates, consider using parafilm or specific sealing mechanisms if there's any risk of aerosolization during transport or incubation. 7. If mixing cultures, do so gently within the BSC. If vortexing, ensure the tube is tightly capped and consider using a mini-vortexer inside the BSC to limit potential aerosol dispersion. 8. Maintain a highly accurate and up-to-date inventory of all BSL-3 culture stocks (including strain, date, quantity, location).

	BSL-1 (Low Risk)	BSL-2 (Moderate Risk)	BSL-3 (High Risk, Aerosol Transmission)
Spore-forming culture handling	All spore-forming cultures in the above BSL1 laboratory. 1. Spores (bacterial or fungal) are highly resistant. They can survive many disinfectants, desiccation, and UV radiation. So, they are challenging to eliminate. 2. Spores are easily aerosolized.	All BSL2 live culture practices, and additionally: 1. Always work in a BSC for all manipulations. This is non-negotiable for spore-forming agents, even for procedures that might seem low-risk with non-spore formers. 2. Avoid or minimize procedures that generate aerosols (e.g., vigorous shaking, sonication, pipetting forcefully, rapid opening of containers). If unavoidable, perform with extreme caution in the BSC. 3. Allow aerosols to settle in the BSC for 5-10 minutes after manipulation before removing items. 4. Immediately after use and after any spills, decontaminate all work surfaces (BSC interior, benchtops) with an effective sporicidal disinfectant, e.g., Chlorine-based disinfectant or Hydrogen peroxide 10-30% with a contact time of 15-20 mins. 5. All equipment (e.g., pipettors, centrifuges, incubators) that comes into contact with spore material must be decontaminated using sporicidal agents or autoclaved. 6. Emphasize rigorous hand washing. Consider using an alcohol-based hand rub after washing hands, though soap and water are paramount for spore removal. 7. Maintain excellent general laboratory cleanliness to prevent accumulation of spores in dust or on surfaces. Use wet methods (e.g., wiping with disinfectant-soaked cloths) instead of dry sweeping/dusting. 8. Store spore stocks in clearly labelled, robust, and potentially double-contained vials/tubes to prevent accidental breakage and dispersal. 9. Consider establishing a baseline health status for personnel working with spore-forming agents.	All BSL-3 live culture practices: 1. Use EPA-approved sporicidal disinfectants (e.g., high concentrations of sodium hypochlorite/bleach, hydrogen peroxide, glutaraldehyde, peracetic acid) with 20-30 min contact times. 2. Avoid the application of disinfectants with the spray method to prevent the formation of aerosols. Pouring disinfectant on the spill covered by a microfibre cloth is sufficient. 3. All work surfaces must be decontaminated daily and immediately after any spill with a validated sporicidal agent. 4. All materials and equipment must be decontaminated before removal from the BSC or the BSL-3 facility. This includes wiping down exteriors of tubes, flasks, and pipettes with sporicidal disinfectant before removing them from the BSC. 5. Use sealed safety cups, safety buckets, or sealed rotors with O-rings. Load and unload tubes and rotors within a BSC. Allow aerosols to settle for at least 10 minutes after a run before opening the centrifuge. 6. Decontaminate the centrifuge interior and accessories if a tube breakage occurs. 7. Autoclaving is the preferred method for inactivating spore-forming organisms in solid and liquid waste. 8. Procedures that create aerosols (e.g., vigorous mixing, sonication, grinding, pipetting) should be minimized or performed with extreme caution within the BSC. 9. Maintain an accurate and up-to-date inventory of all spore-forming agents. 10. Consider implementing environmental monitoring (e.g., surface swabbing) to detect the presence of spores in the laboratory, especially after decontamination procedures. 11. Consider establishing a baseline health status for personnel working with spore-forming agents.

	BSL-1 (Low Risk)	BSL-2 (Moderate Risk)	BSL-3 (High Risk, Aerosol Transmission)
Organisms' Genetic Materials Handling Practices (includes recombinant DNA (rDNA), synthetic nucleic acid molecules, and any cells, organisms, or viruses containing such molecules	1. Standard microbiological practices 2. The risk assessment of the specific genetic material determines the appropriate containment level, e.g., nature of insert, host organism, & vector characteristics	All BSL2 practices and additionally: 1. Transport all genetic materials within the facility in durable, leak-proof primary containers placed within a secondary, leak-proof container (e.g., a sturdy tray or bucket) to prevent spills. 2. Avoid public areas during transport if materials are moving outside the immediate lab space.	All BSL3 practices 1. For work involving indigenous or exotic agents, e.g., Mycobacterium tuberculosis, SARS-CoV-2, HIV, rabies virus, West Nile virus, and various highly pathogenic bacteria and viruses, including their genetic material.

	BSL-1 (Low Risk)	BSL-2 (Moderate Risk)	BSL-3 (High Risk, Aerosol Transmission)
Attenuated culture handling	1. Standard microbiological practices 2. No eating/ drinking in the lab 3. Wash hands 4. Always use pipetting aids. Never mouth pipette.	Adhere to BSL-2 live cultures handling practices. 1. Even if attenuated, understand the specific attenuated strain, its parent strain's virulence, any residual pathogenicity, potential for reversion to virulence, and known transmission routes. 2. Attenuated infectious materials should be stored in a lockable freezer or designated laboratory room. 3. Always handle attenuated BSL-2 cultures diligently	Adhere to BSL-3 live cultures handling practices. 1. While its virulence is reduced, "attenuated BSL-3" cultures still possess characteristics that necessitate handling within a BSL-3 facility due to their potential for aerosol transmission and ability to cause severe disease. 2. Immunocompromised individuals might be susceptible to infection by the attenuated or vaccine strain. Therefore, never compromise on BSL-3 containment measures when handling these agents. 3. Always handle attenuated BSL-3 cultures diligently.

5.1.1 Hazardous Equipment

a. The equipment must be properly installed, maintained, and calibrated.
b. All hazardous equipment must have a senior staff member or student responsible for training, maintenance, and upkeep.
c. Only trained users can operate the equipment.
d. Users must read the equipment manual before using and follow the SOP.

5.1.2 Hot Air Oven

a. Wear PPE as per the guidelines. Heat-resistant gloves may be required.
b. Don't plug the hot air oven into an extension cord.
c. Don't overload the hot air oven.
d. Don't exceed the operating temperature limits.
e. Don't use mercury thermometers to monitor temperatures. They tend to break.
f. If you have a model with an exposed heating element on the bottom, do not place items on the shelf that can potentially fall onto the heating element.
g. Never put flammable, combustible, reactive, or corrosive materials inside. High-temperature-intolerant materials can cause fire.
h. Be cautious of hot surfaces when loading and unloading.
i. Keep your face, body, and hands away from the escaping heat when opening the machine door.
j. Residual chemicals may volatilize, causing an inhalation hazard. Clean the equipment to remove residual chemicals before using.

5.1.3 Biosafety Cabinet

A biosafety cabinet (BSC) should be selected primarily based on the type of protection needed.

a. Start-Up
   - Wear PPE.
   - To minimize cross-contamination, materials considered "clean" must be at least 150 mm away from aerosol-generating objects.
   - Biohazard collection bags should be inside the cabinet.
   - Use absorbent pads on the work surface to minimize splatter or aerosol in case of a spillage.
   - Do not obstruct the front or back air grilles.
b. Operations
   - Minimize movements to avoid disrupting cabinet airflow.
   - Please do not use a gas flame, as it interferes with airflow.
c. Shut Down
   - Seal biohazard bags.
   - Decontaminate the items before removing them from the cabinet.
   - Decontaminate the surface of the cabinet inner sidewalls, back wall, work surface, drain pan, and the inner side of the sliding sash/hinged window.

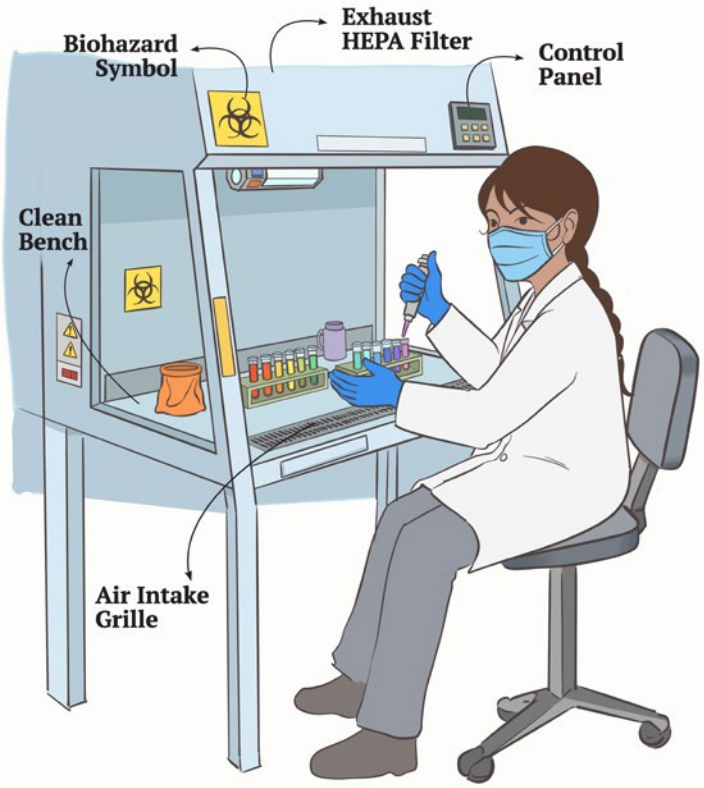


Fig 5.1 Work inside the Biosafety Cabinet and prevent contamination

5.1.4 Incubator

a. The incubator should be switched off when not in use.
b. Do not overload the incubator.
c. Disinfect the incubator every 6 months or in case of a spill. Before disinfection, disconnect the incubator plug from the main socket.
d. Use 70% ethanol to clean metallic surfaces (i.e., racks, floors, walls, and doors) of the incubator.
e. The temperature of the incubator must be calibrated.
f. Re-calibration is mandatory if the incubator has been repaired, cleaned, or restarted after a power failure.

5.1.5 Autoclave

a. An autoclave sterilizes items using heat and pressurized steam. Laboratories commonly use autoclaves to sterilize glassware, non-electronic instruments, media and solutions, and biohazardous waste.
b. Record cycle information on the autoclave log sheet or logbook.
c. PPE
   - Always wear the minimum PPE when using an autoclave. Refer to PPE Guidelines.
   - To prevent burns from heat and steam, use long heat-resistant gloves
d. Pre-Inspection
   - Inspect the door gasket (seal) for cracks or bulges. The gasket should be smooth and pliable.
   - Clean the drain screen of debris.
   - Inspect for spills or debris inside the autoclave.
   - Contact the equipment in charge if you notice any problems. Do not use the autoclave.
e. Autoclaveable Items
   - Do not autoclave flammable, combustible, reactive, corrosive, toxic, or radioactive materials.
   - All plastics must be autoclavable.
   - Inspect glassware for cracks. Do not autoclave cracked or compromised glassware.
   - Loosen the caps of liquid-filled vials or cover them with foil. This allows the steam to penetrate the vial and prevent an explosion.

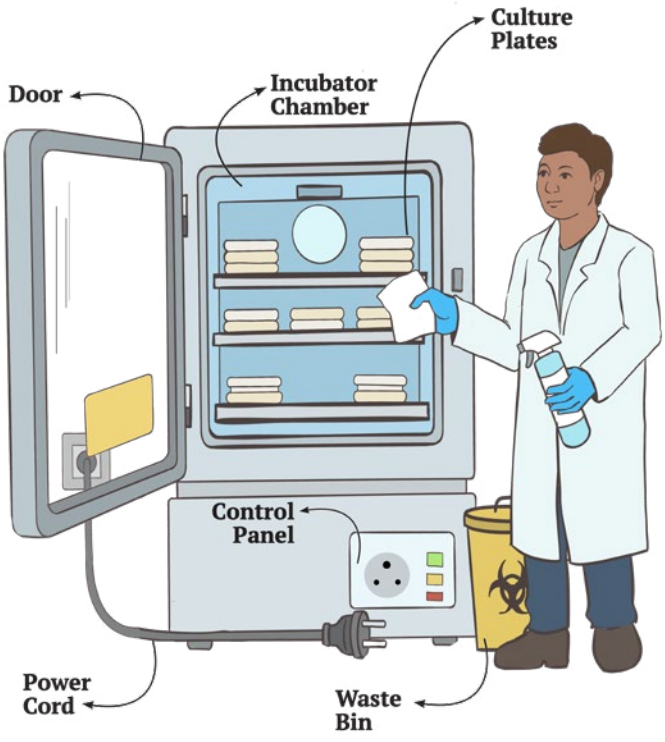


Fig 5.2 Incubator parts and cleaning points



Fig 5.3 Autoclave parts and safe loading of biohazard bags

- Bagged items should be tied or taped loosely. Steam must be able to penetrate the bag.

f. Load
   - Place items in an autoclave tub on a rack. Never place items directly on the autoclave bottom or floor.
   - Always use secondary containment, just in case of spillover.
   - Ensure that the autoclave has reached sufficient pressure to start a cycle.
   - Do not overload the autoclave. Allow adequate space between items for steam.
   - Check the water level.
   - Make an entry in the logbook.

g. Unload
   - Never open an autoclave door during a cycle! If necessary, abort the cycle and wait until the chamber depressurizes.
   - If the cycle fails, notify the equipment in charge. Items may not be sufficiently decontaminated if the cycle is not completed.
   - Before unloading, verify that the chamber temperature has dropped and the pressure is zero.
   - Slowly open the door to let out steam gradually. Keep your face away from the door.
   - Allow items to stand in the autoclave for 10 min. Cautiously remove items and place them in a safe area to cool. Do not agitate containers, as boiling or superheated liquids can explode if moved too quickly.
   - Make an entry in the logbook.

5.2

Infrastructure, PPE & Systems

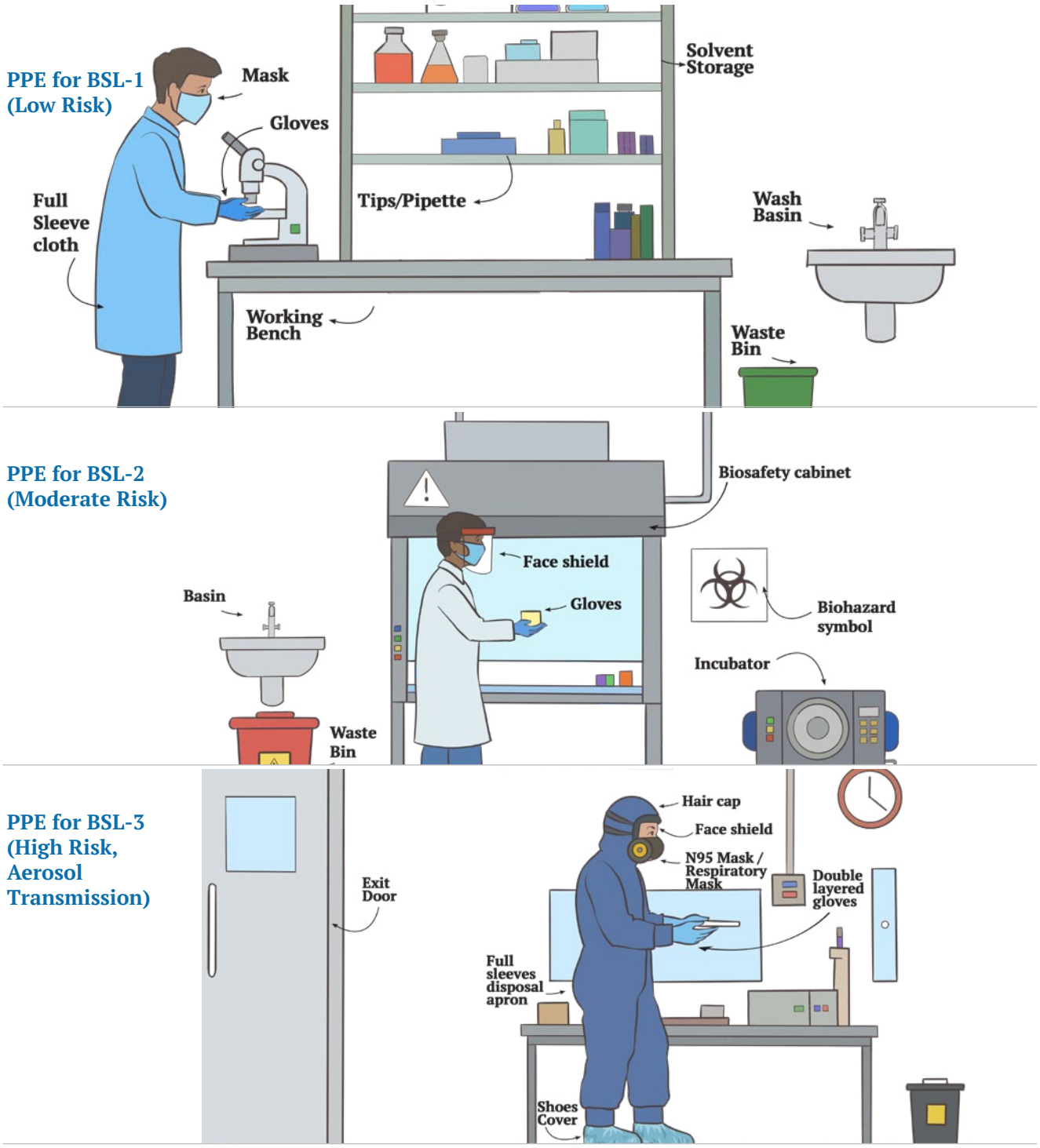


Fig 5.4 PPE for BSL-1, BSL-2, and BSL-3 Laboratories

Table 5.2 Biosafety Level (BSL) Classification and Requirements

	BSL-1 (Low Risk)	BSL-2 (Moderate Risk)	BSL-3 (High Risk, Aerosol Transmission)
Type of microorganisms	Not known to consistently cause disease in healthy adults (e.g., non-pathogenic E. coli, etc).	Indigenous or exotic agents pose a moderate hazard; they can cause human disease but are usually treatable. (e.g., Staphylococcus aureus, Salmonella, Bacillus species, Clostridium species in their spore state, or fungal spores).	Indigenous or exotic agents with potential for aerosol transmission can cause serious or potentially lethal disease (e.g., Mycobacterium tuberculosis, Yellow Fever, SARS-CoV, Influenza, etc).
Laboratory Infrastructure	1. Open benchtop worktable. 2. A sink for hand washing. 3. Lockable doors. 4. Non-porous, easily cleaned surfaces (floors, benches, chairs). 5. Incubators 6. Oven 7. Other equipment as per the BSL1 requirements 8.Pest control.	All BSL-1 infrastructure, and additionally: 1. Self-closing doors. 2. Biosafety cabinets (Class I or II) for aerosol-generating procedures. 3. Access to an autoclave or other decontamination methods. 4. Eyewash station. 5. Vacuum lines with HEPA filters. 6. Other equipment as per the BSL2 requirements. 7. Mechanical ventilation with inward airflow is recommended.	All BSL-2 infrastructure and additionally: 1. Physical separation from public access corridors. 2. Self-closing, double-door access (e.g., through an anteroom). 3. Biosafety cabinets Class II or Class III. 4. A dedicated ventilation system with non-recirculated, HEPA-filtered exhaust air. 5. Sustained negative airflow into the laboratory (air pressure gradient). 6. Walls, floors, and ceilings should be sealed and easily decontaminated. 7. The hand-washing sink near the exit has hands-free operation. 8. Autoclave within the lab or immediately adjacent.
Personnel Protective Equipment (PPE)	1. Please see the PPE guidelines 2. Lab coats, gloves. 3. Eye protection/ face shields when a splash hazard exists.	1. Please see the PPE guidelines 2. Gloves. 3. Eye protection and face shields as needed. 4. Dedicated lab coats for cell culture work.	1. Please see the PPE guidelines. 2. Protective lab clothing (solid-front wraparound gowns, scrub suits, coveralls). 3. Gloves (double). 4. Respiratory protection (e.g., N95 mask, & respirators).
Training & Qualification	Basic lab safety & hygiene	1. Comprehensive training on specific hazards, PPE, and BSC usage procedures (spills, exposures). 2. All personnel handling spore-forming agents must receive specific training on the unique risks and decontamination procedures for spores.	1. Extensive, specialized training and expertise in BSL-3 practices. 2. Regular emergency response training (Spill, medical, containment breach). 3. Proficiency testing for aseptic technique, biosafety knowledge, and equipment operation. 4. A thorough medical status (immunocompromised, allergic reactions, latent disease, chest X-rays, vaccine status) is required.

| 5.3 |

Spill Control

a. Ensure the Bio-safety kit is readily available and fully stocked at all BSLs.
b. Remain Calm: Assess the situation without panic.
c. Self-Protection: Don appropriate PPE before initiating cleanup as mentioned in the IISc safety manual.
d. Contain & Decontaminate: Prevent spread and neutralize the biological agent.
e. Safe Disposal: Properly dispose of all contaminated materials.
f. Report and Document: Ensure all incidents are recorded for improvement and compliance with the OLSEH Guideline.

5.3.1 Bio Spill Kit Contents

a. BSL-1 & BSL-2: Freshly prepared 10% household bleach solution (1:10 dilution of 5.25% sodium hypochlorite), or other lab-approved broad-spectrum disinfectant.
b. BSL-3: Highly effective broad-spectrum disinfectant validated for the specific agents handled (e.g. higher concentration of bleach, peracetic acid, or specialised virucidal/sporocidal agents). Ensure sufficient quantity.
c. Absorbent materials: Paper towels, absorbent pads, spill pillows.
d. Biohazard bags: Leak-proof, autoclavable (especially for BSL-2 and BSL-3).
e. Sharps container: Puncture-resistant.
f. Tools: Forceps/tongs, dustpan, and brush (for broken glass).
g. Personal Protective Equipment (PPE):
    - BSL-1: Disposable gloves, lab coats, safety glasses.
    - BSL-2: Disposable gloves (consider double gloving), lab coat/disposable gown, safety glasses/goggles, face shield.
    - BSL-3: Full body coverage (e.g. disposable coveralls/Tyvek suit), double gloves, head cover/bonnet, shoe covers, full face shield, and respirator (N95 or higher, or powered air-purifying respirator (PAPR) depending on risk assessment and agent).
h. Warning signs: “DO NOT ENTER” / “BIOHAZARD SPILL”
i. Incident report forms.

5.3.2 BSL-1 Spill

Agents: Well-characterised agents not known to cause disease in healthy adults (e.g. E. coli K-12, Saccharomyces cerevisiae).

a. Alert others in the immediate area to prevent further contamination.
b. Don appropriate PPE – lab coat, disposable gloves, and safety glasses.
c. Cover the spill with absorbent material (e.g. paper towels).
d. Carefully pour disinfectant (e.g., 10% bleach solution) over the absorbent material, working from the edges inward to prevent spreading.
e. Allow recommended contact time for the disinfectant (typically 15-20 minutes).
f. Wipe up the spill from the edges to the centre using fresh absorbent material. If broken glass or sharps are present, use forceps or tongs to pick them up and place them directly into a sharps container. NEVER use your hands.
g. Clean the spill area again with fresh absorbent material soaked in disinfectant.
h. Dispose of all contaminated materials (used PPE, absorbent materials, etc.) into a biohazard bag.
i. Remove PPE and dispose of it in the biohazard bag.
j. Wash your hands thoroughly with soap and water.
k. Report the incident to your PI and department safety champion.
l. File an incident report and submit it to OLSEH.

5.3.3 BSL-2 Spill

Agents: Agents associated with human disease, but with low individual risk (e.g. Staphylococcus aureus, Salmonella, non-aerosolised Mycobacterium tuberculosis cultures, etc).

a. Small spill (e.g. a few drops to a few milliliters, no aerosol generation outside BSC):
   - Ensure absorbent materials and biohazard bags are autoclavable if the waste requires autoclaving before disposal.
   - Follow steps 1-11 of BSL-1 Spill Procedure.
b. Spill Inside a Biological Safety Cabinet (BSC):
   - Leave the BSC blower on. Do not turn off the BSC.
   - Don appropriate PPE – lab coat, gloves, and eye protection.
   - Cover the spill with absorbent material.
   - Carefully pour disinfectant over the absorbent material and the spill.
   - Allow appropriate contact time, wipe the spill with paper towels, and work from the edges to the centre. Use forceps for broken glass/sharps.
   - Wipe down all interior surfaces of the BSC (work surface, walls, drain pan/catch basin if accessible) with disinfectant.
   - Autoclave all cleanup materials (paper towels, gloves, etc.) before discarding them into the biohazard waste stream.
   - Wash your hands thoroughly.
   - Report the incident to your PI and department safety champion.
   - File an incident report and submit it to OLSEH.



Fig 5.5 Biological spill kit contents and cleanup steps

c. Large Spill or Potential for Aerosol Generation (outside BSC):
   - DO NOT PANIC!
   - Immediately vacate the area. Alert others to evacuate the laboratory.
   - Close doors to the affected area to contain aerosols.
   - Post "DO NOT ENTER" / "BIOHAZARD SPILL" signs on all entrances.
   - Allow aerosols to settle for at least 30 minutes (this allows for air changes and settling of airborne particles).
   - Contact your PI, department safety champion, and OLSEH/Biosafety Officer immediately.
   - Provide details: Location, approximate volume, type of material, and any known hazards.
   - Don full appropriate PPE from the spill kit: lab coat/disposable gown, double gloves, safety glasses/face shield, shoe covers, and an N95 respirator if inhalation risk is present.
   - Enter the room cautiously, cover the spill with absorbent material, working from the edges inward.
   - Carefully pour disinfectant (e.g. 10% bleach solution) over the absorbent material and the entire spill area, starting from the perimeter and working towards the centre. Avoid splashing or creating new aerosols. Ensure complete saturation.
   - Allow adequate contact time (typically 20-30 minutes, or longer for high organic load like blood). Use forceps/tongs for sharps; dispose directly into a sharps container.
   - Re-disinfect the entire spill area and any potentially contaminated surfaces (benches, equipment, walls).
   - Dispose of all contaminated materials into autoclavable biohazard bags.
   - Remove PPE in a manner that avoids secondary contamination. Dispose of all disposable PPE in the biohazard bag.
   - Autoclave all biohazard waste as per institutional guidelines before final disposal. Wash your hands thoroughly with soap and water.
   - File an incident report and submit it to OLSEH.

5.3.4 BSL-3 Spill

Agents: Indigenous or exotic agents that may cause serious or potentially lethal disease through inhalation (e.g. Mycobacterium tuberculosis (aerosolised), Brucella spp., SARS-CoV-2, etc.).

a. Evacuate:
   - DO NOT PANIC!
   - Immediately vacate the BSL-3 laboratory/suite.
   - Alert all personnel in the BSL-3 suite to evacuate immediately.
   - Activate emergency alarms and immediately notify the Security, PI/lab supervisor, and Biosafety officer/OLSEH.
   - Close all doors to the BSL-3 suite and ensure primary airlock doors are secured.
   - Post "DO NOT ENTER" / "BIOHAZARD SPILL - BSL-3 HAZARD" signs on all entrances.

b. Cleanup by trained personnel:
   - PIs, the facility in-charge, and the Biosafety officer/OLSEH will coordinate the response.
   - Allow aerosols to settle for at least 30-60 minutes, or longer as determined by risk assessment and ventilation system capabilities (e.g. multiple air changes). The directional airflow system of BSL-3 should assist in containment.
   - Assess the situation remotely (if possible) and plan the cleanup strategy, considering the spill's specific agent, volume, and location.
   - Restrict lab access to only authorised cleanup personnel.
   - Designate a cleanup team of at least two fully trained individuals.

c. Spill Cleanup (by trained personnel only):
   - Don full, appropriate PPE for BSL-3 work, ensuring proper donning sequence and seal (e.g. disposable coveralls/Tyvek suit, double gloves, shoe covers, head cover, full face shield, and N-100 respirator with proper fit-testing or N95 Mask with a three-layered one normal mask). Consider a liquid-resistant outer layer when dealing with large liquid spills.
   - Ensure the bio spill kit is complete and readily

available outside the contaminated area before entry.
- Enter the BSL-3 lab/suite cautiously.
- Carefully cover the entire spill area with absorbent material to minimise aerosol generation.
- Slowly pour highly effective disinfectant (validated for the specific agent, often a higher concentration of bleach, or other virucidal/sporocidal agent) around the edges of the spill, working inward. Ensure complete saturation. Avoid splashing.
- Allow extended contact time for the disinfectant (e.g. 30 minutes or more, depending on the agent and disinfectant specifications).
- Carefully collect all contaminated materials (absorbents, disposable PPE, broken glass/sharps in sharps containers) using mechanical means (forceps, tongs, scoop). Place everything into autoclavable biohazard bags.
- Thoroughly disinfect all potentially contaminated surfaces (work surfaces, equipment, walls, floor, handles, light switches, BSC exterior) with fresh disinfectant. This may require multiple wipes.
- If the spill was in a BSC and containment was compromised, the BSC itself must be decontaminated, possibly through gas decontamination using formaldehyde, chlorine dioxide, and hydrogen peroxide, by trained personnel after the immediate spill cleanup.
- Clean the spill area again with fresh disinfectant.

d. Doffing & Decontamination:
   - Perform doffing of PPE in the designated BSL-3 exit area/anteroom following a strict, pre-determined sequence to prevent contamination of personal clothing.
   - Place all disposable PPE into autoclavable biohazard bags.
   - Autoclave all biohazard waste generated from the spill cleanup and contaminated PPE immediately, per institutional and BMW2018 guidelines. This is critical for BSL-3 waste.
   - Wash your hands thoroughly with antiseptic soap and water.

e. Post-Spill & Reporting:
   - File an incident report and submit it to OLSEH.
   - Replenish the BSL-3 spill kit.
   - Consider environmental monitoring (e.g. surface swabs) to confirm complete decontamination, especially for high-risk agents.

5.3.5 Spill On Body/Clothing

a. Immediately remove contaminated clothing while minimising contact with skin.
b. Wash exposed skin thoroughly with antiseptic soap and water for at least 15-20 minutes.
c. Immediately flush eyes at an eyewash station for at least 15 minutes for eye exposure.
d. Seek immediate medical attention. This is critical for BSL-2 or BSL-3 agents, and post-exposure prophylaxis (PEP) may be necessary. Inform the IISc Health Centre of the specific agent.
e. File an incident report and submit it to OLSEH.
f. Contaminated clothing should be placed in an autoclavable bag for proper decontamination (e.g., autoclaving or specialised laundry).

5.3.6 Biowaste Disposal As Per BMW Rules, 2018

Category	Type of Waste	Colour and Type of Container	Treatment and Disposal Options
Yellow 	1. Human Anatomical Waste (human tissues, organs, body parts) 2. Animal Anatomical Waste 3. Soiled waste (items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs, bags containing residual/ discarded blood and blood components), expired or discarded medicines 4. Microbiology, Biotechnology & Clinical Lab Waste (lab cultures, microbial stocks, specimens, live/attenuated vaccines)	Yellow colour non-chlorinated plastic bags or containers (with biohazard symbol)	1. Incineration, Plasma Pyrolysis, or Deep Burial (for specific cases like human anatomical waste). 2. Discarded blood bags are counted, sealed, weighed, autoclaved on site, then sent in a yellow bag for incineration by CBMWTF.
Red 	Contaminated waste (Recyclable) such as tubing, drains, oxygen masks, intravenous tubes, urine bags, gloves, and disposable items other than sharps	Red colour non-chlorinated plastic bags and containers (with biohazard symbol)	Autoclaving followed by Recycling. Needles of syringes must be cut/destroyed with a needle destroyer/cutter before putting them in red bags.
White 	Waste Sharps, including metals (needles, syringes with fixed needles, needles from needle tip cutter/burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts)	White colour, puncture-proof, leak-proof, tamper-proof containers (with biohazard symbol)	Autoclaving or Dry Heat Sterilisation in the lab, followed by Shredding or Chemical Treatment in an authorised common biomedical waste treatment facility.

CHAPTER 6

Electrical & Fire Safety

Electrical and fire safety are essential in laboratories due to the use of electrical equipment and flammable materials. Improper use or poor maintenance can lead to accidents and fire hazards.

This section provides basic guidelines to prevent risks and ensure safe operation. All personnel must follow these practices to maintain a safe working environment.

6.1

Best Practices

a. The best defence against electrical fire is prevention.
b. Beware of ignition sources like open flames, heat, and high-power equipment.
c. Ensure adequate ventilation around objects that heat up e.g. furnaces, hot plates, ovens, batteries, etc.
d. Reduce fire load in the lab. This means minimising combustible items in the lab.
e. Papers, binders, and manuals must be stored in enclosed cupboards, away from hot objects.
f. Keep your workspace neat. Avoid the accumulation of combustible materials like carton boxes, packaging, thermocol, rags, paper waste, wipes, and chemical waste.
g. Locate the closest fire exits, fire alarms, and extinguishers into your laboratory.
h. Each laboratory should be equipped with fire extinguishers. Contact OLSEH if you don't have one in your lab or if it is not being serviced regularly.
i. Please learn the use of a fire extinguisher. OLSEH conducts regular fire extinguisher training.
j. Please know your evacuation route and nearest exits. OLSEH conducts regular mock fire drills.
k. Maintain a minimum of 2 feet of walking space to exits.
l. Do not block access to fire escape routes. For example, the stairs should be free of debris, nothing should be stored in front of fire hoses, etc.
m. Power Distribution Boards (PDB) needs to be labeled as per the power supply given and taken.
n. Daisy chaining of the electrical extension cords to be avoided.
o. Keep all electrical sources like sockets, wires, electrical extension cords etc. away from water sources.

6.2

Electrical Safety

a. Access to electrical plugs and switches should be unobstructed. There should be no barrier to electrical panels and MCBs.
b. Ensure that electrical cords are in good condition.
c. No live electrical terminals should be exposed. Don't use splicing, insulation tape, and other forms of jugaad. Use professionally installed electrical points and terminal boxes.
d. Don't overload an electrical outlet, e.g., don't connect a 15 A device to a 5 A socket.
e. Minimise the use of power strips and extension cords. Daisy-chain extension cords are not a replacement for permanent plug points.
f. Do not run cords through doorways or walkways. Users can trip over them. Footfall inevitably damages the wires, leading to shorts and fires. Wires should always be in conduits on ceiling or walls. If cables must be on floor, use floor cord covers, not carpets.
g. Electrical equipment must be properly earthed. The earth resistance must be less than 5 Ohm, preferably less than 2 Ohm. The earth pits must be maintained.
h. Two-pin appliances (ungrounded) must not be within 5 feet of flammable materials.
i. All labs must have electrical panels with circuit breakers. Ground fault circuit breakers are mandatory for high power equipment.
j. Safety devices (e.g., fuses) on electrical equipment should not be bypassed.
k. Electrical equipment must be disconnected during servicing.
l. Do not disconnect the power supply by pulling or jerking the cord from the outlet.

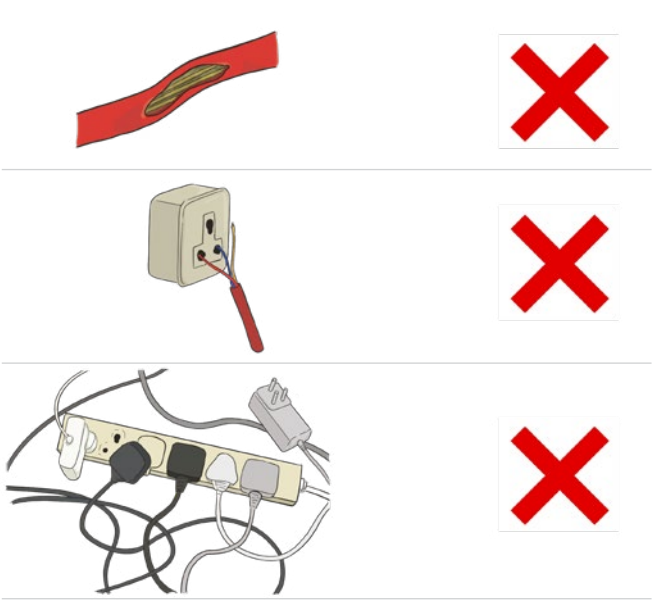


Fig 6.1 Avoid these bad practices

m. Electrical connections must not be handled with wet hands or near water.
n. Don't extinguish an electrical fire with water.
o. All fans, exhausts and AC units should have cooling intervals during prolonged use to prevent overheating, equipment failure, and fire risk. Ensure regular maintenance.

6.3

Heated Equipment

a. Be careful of devices that heat up during operation, like hot plates, box furnaces, heating mantles, hot air guns, and oil baths.
b. The unit should ideally have an automatic safety shutoff that triggers in case of overheating.
c. Heating units without an automatic shutoff cannot run unattended.
d. Maintain the equipment as per the manufacturer's specifications.
e. Flammable or combustible solvents should not be near a heated bath. Oil baths must always be housed in a chemical fume hood.
f. Make sure there is adequate ventilation around heated equipment.

6.4

UPS & Batteries

a. UPS is a common but significant fire risk.
b. Vented lead-acid batteries generate some hydrogen and oxygen during operation. Inadequate ventilation and ignition sources can cause explosions.
c. Batteries also have hot acids, so chemical hazards are severe.

6.4.1 Battery Types

UPS uses three kinds of batteries: vented lead-acid (VLA), valve-regulated lead-acid (VRLA), and sealed or maintenance-free lithium-ion batteries. In addition, labs can have lithium-polymer and commercial consumer-grade batteries.

6.4.2 Vented Lead-Acid (VLA) Batteries

a. Vented lead-acid batteries are commonly called "flooded" or "wet cell" batteries.
b. VLAs are exceptionally reliable, so failures are uncommon until halfway through their 20-year pro-rated life. The most common failure is a short circuit, and even that is not an emergency, provided the fault is localised.
c. VLA batteries are immune to thermal runaway, a condition that plagues VRLA batteries.
d. Flooded lead-acid batteries can be charged at high voltage settings, which improves performance.
e. VLA batteries have lead plates submerged in sulphuric acid electrolyte. The electrolyte depletes over time, so distilled water must be added periodically.
f. Acid is corrosive, so workers must wear PPE when servicing the batteries. Acid also reacts violently with metals, strong oxidisers, and water. Contact with metals may produce toxic sulphur dioxide fumes and flammable hydrogen gas.
g. Also, hydrogen is produced during charging. The hydrogen is evacuated through vents. Hydrogen is highly flammable and explosive, so VLA batteries must be installed in a dedicated battery room with six air changes per hour.

6.4.3 Recombination Valve-Regulated Lead-Acid (VRLA) Batteries

a. VRLA batteries are sealed, usually with polypropylene. Also, the electrolyte is immobilised in a gel or absorbent glass mat. So, there is no sloshing acid that can leak.
b. The oxygen generated from the positive electrode during charging diffuses to the negative electrode, producing water:
c. $Pb + H_2SO_4 + ½O_2 \rightarrow PbSO_4 + H_2O$
d. The reaction suppresses hydrogen evolution at the negative electrode, allowing the cell to be sealed. The recombination efficiency is not 100%, so some H_2 is released.
e. "Valve-regulated" refers to the method of H_2 release. The valve will vent when it reaches a certain pressure, generally below 10 psig.
f. VRLA batteries produce 60 times lower H_2 than VLA. So, they can be housed without active ventilation. VRLA batteries don't need a dedicated room either.
g. However, VRLA batteries are prone to "thermal runaway", triggered by charger overvoltage. To prevent the failure, the safety valves open and the battery vents hydrogen until the temperature and/or voltage are reduced.
h. VRLA batteries are usually set to a lower voltage limit, which shelters the battery at the cost of lower performance.

6.4.4 Lithium Ion Batteries

a. Compared to lead-acid, lithium-ion batteries are of a small size, lightweight, have a high cycle-count (charge-discharge cycles), faster recharge times, and built-in battery management (not just monitoring).
b. Thermal runaway in lithium-ion batteries has received a lot of attention. To control it, Li batteries have a battery management system (BMS) in each battery, as well as a system-level master controller. The BMS manages charge current, voltage, and cell voltage balance, reducing the chance of overtemperature.
c. If temperatures rise above safe levels, the BMS will independently disconnect the battery or string via multiple different means and notify the user via the battery cabinet monitor and an alarm on the UPS.

6.4.5 Lithium-Polymer (LiPo) Batteries

a. High energy density, lightweight, and widely used in drones, robotics, portable electronics, and lab prototypes.
b. Chemically unstable compared to cylindrical lithium-ion cells. Require special care in charging and storage.
c. Store at 15–25°C; avoid freezing or overheating.
d. Store at 30–50% charge (3.7–3.9 V/cell).
e. Very low internal resistance → can discharge at high current rates.
f. Flexible pouch construction (not rigid casing) → prone to mechanical damage and swelling.
g. Require Battery Management System (BMS) for safe charging/discharging.
h. Charge on non-flammable surfaces, away from flammable materials.
i. Never leave Li-Po batteries charge unattended.

6.4.6 Small Consumer Batteries

a. These are consumer-grade small batteries e.g., primary (non-chargeable) AA, AAA, C, D, 9V, coin/button cells, or secondary (rechargeable), NiMH (AA/AAA), lithium coin cells (LIR series).
b. The capacities are small, so they are usually safe. However, they can present hazards if mishandled, especially button cells and rechargeable batteries.
c. Old or over-discharged cells may leak KOH, NaOH, or $ZnCl_2$, which are corrosive
d. Loose storage may cause short circuit, heat build-up, or burns.
e. Rechargeable NiMH or lithium coin cells can overheat and catch fire.

6.4.7 Good Practices

Read the datasheet and MSDS of batteries.

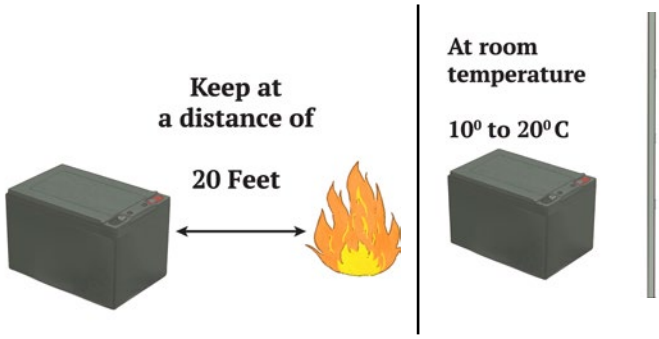
a. Store batteries in a cool place, away from sunlight. The ideal storage temperature for most batteries

is 10°C and 20°C. However, this differs, so consult the label.

b. Keep the battery away from sparks, heat sources, or fire. Do not store batteries near other hazards like cylinders and chemicals. There must be a separation, like a physical barrier or 20 ft of space.
c. The batteries and control electronics produce heat. The installation must be in a ventilated area.
d. Lead-acid batteries need ventilation. VLA batteries need active ventilation, else H_2 may build up.
e. Do not store loose battery cells together as this poses a risk of short circuit.
f. Recharge batteries only with recommended chargers with well-designed battery management systems (BMS). BMS monitor and manage cell voltage, cell current, cell temperature, cell charge balancing, charge control, and internal short circuit detection.
g. Overcharging a battery can result in thermal runaway. Monitoring the state of charge is essential.
h. Do not mix batteries with different ages, capacities, makes, or chemistries.
i. Regular periodic maintenance goes a long way towards preventing unsafe situations.
j. Remove small batteries from portable devices if unused for long periods.
k. Old batteries must be replaced before end-of-life. Old, uncharged, or undercharged batteries may have built-up gases, which can explode. If you see a deformed or "bubbled" battery, do not charge it.
l. Electrolyte spills must be handled as a chemical spill. Use non-combustible spill kits. Do not discharge un-neutralised acid to the sewer.

Table 6.1: Common issues related to batteries & UPS that must be avoided

S. No.	Issues
1.	VLA batteries should be stored in a separate cabin with active ventilation of 6 ACH.
2.	UPS and batteries stored together.
3.	Poor housekeeping. Battery is surrounded by empty cartons, packages, etc.
1.	VRLA batteries cannot be stored in a poorly ventilated or congested area. Batteries should not be beneath tables, inside closed cabinets, etc.
2.	Battery is sharing storage with a metal toolbox.
1.	VRLA batteries cannot be stored in a poorly ventilated or congested area.
2.	UPS and batteries are stored together.
3.	Poor housekeeping. Battery covered with dust and near empty boxes, packaging, and wires.
1.	Poor housekeeping. Battery covered with dust.
2.	Wash basin (water) near the battery.
3.	Drips from basin are arrested by a bucket (jugaad tech)!
1.	VRLA batteries cannot be stored in a poorly ventilated area.
2.	Compressed gas cylinder is installed near the battery.
1.	UPS and battery are stored together.
2.	Poor housekeeping near the battery.



6.4.8 Battery Room

a. The battery room for lead-acid batteries should be well-ventilated. Forced air ventilation is preferred. Simple windows are not enough. A good practice is to install an inverted funnel exhaust for each battery. Exhaust fans or blowers may be interlocked to switch ON if gas sensors detect H_2.
b. The fresh air volume of the battery room must meet EN50272-2001 requirements.
c. The ambient temperature must be stable. Temperature is a major factor in determining battery life and capacity. The nominal operating temperature of the battery is 20°C.
d. Keep batteries away from heat sources.
e. Batteries may get damaged during transport. Before installation, visually examine any dampness, water, or damage to the packaging of a new shipment. Do not install or charge damaged batteries.
f. Batteries should be mounted on racks and trays which are resistant to the electrolyte.

Table 6.2: Summary of storage requirements for batteries

	Vented Lead-acid (VLA)	Valve-Regulated Lead- acid (VRLA)	Lithium-Ion Batteries
			
Separate Storage area	Required	Not required	Not required
Ventilation	Forced ventilation with 6 ACH	Passive ventilation is ok	Passive ventilation is ok
Ideal temperature	10-20°C	10-20°C	10-20°C
Distance from other hazards	20 feet separation or physical barrier from heat sources, gas cylinders, etc.		
Housekeeping	No dust accumulation		
PPE for the storage area	Electrical safety shoes, goggles and acid-resistant gloves	Electrical safety shoes	Electrical safety shoes
Access control	Entry only for specifically trained personnel	General entry allowed	General entry allowed
Signboards	Entry restricted; Electrical hazard 	Electrical hazard 	Electrical hazard 

g. Use a secondary containment to collect any acidic drips. Otherwise, the floors shall be acid-resistant.
h. Recommended personal protective equipment for the battery room is acid-resistant face shields, goggles, gloves, aprons, and boots.
i. Safety shower and eye-wash station must be within 25 feet of the battery room.

6.4.9 UPS Room

a. It is preferable to install the UPS away from the batteries. The batteries can be located in a separate room, with a DC bus connecting the UPS and the battery.
b. The UPS room should be ventilated so the electronics do not overheat.
c. There must not be any sources of ignition nearby.
d. The distribution panel connecting the batteries, UPS, and load must have electrical protections like circuit breakers.

6.4.10 End-Of-Life & Disposal

a. Batteries must not be disposed in general waste. Do not incinerate or "break" battery before disposal.
b. Batteries must be discharged fully before disposing.
c. OLSEH will arrange the pickup of all types of batteries. Users are required to fill out the electronic form circulated through the Campus Bulletin.
d. Batteries are picked up from designated hazardous e-waste bins.

6.5

Fire Extinguisher

a. IISc has installed fire extinguishers in all departments and residential buildings across the IISc campus, including Challakere. Fire extinguishers are maintained by OLSEH through an external vendor. For any concerns, please contact safety.olseh@iisc.ac.in.
b. Learn how to operate a fire extinguisher. The mnemonic PASS is often used to describe fire extinguisher usage.
c. Use the correct type of extinguisher. The lab must have extinguishers for the types of hazards that are likely to occur.
d. Fire classification changes with country. For the purpose of this document, we shall follow the Australian/European system that goes from A to F.
e. During mock drills, OLSEH demonstrates the use of fire hydrants. Security staff are trained to use fire hydrants.

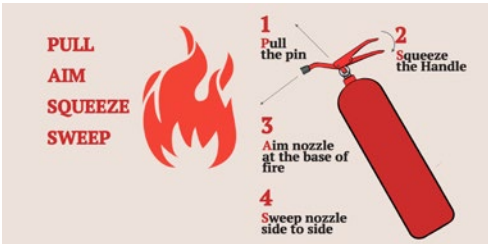
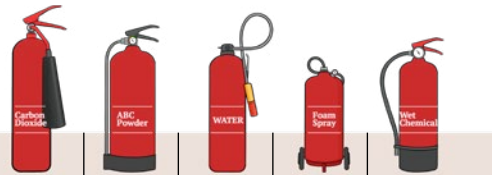


Fig 6.3 How to operate a fire extinguisher (PASS technique)

6.6

Other Fire Safety Infrastructure

a. All labs must periodically evaluate their fire preparedness.
b. Depending on the hazards, the department may need fire alarms, sprinklers, fire detectors, etc. OLSEH is responsible for installing and maintaining fire safety infrastructure in all labs. If you are missing something, please contact safety.olseh@iisc.ac.in.
c. All multi-storey buildings must have an operational fire hydrant loop. OLSEH maintains fire hydrant systems across campus through an external vendor. During mock drills, OLSEH demonstrates the use of fire hydrants. Security staff are trained to use fire hydrants.
d. All buildings with significant gas, electrical, or chemical hazards should have a sprinkler system. OLSEH has installed these in all departments buildings. OLSEH maintains sprinkler systems across campus through an external vendor.
e. As per the Indian Building Code, all buildings of a certain size need fire alarm systems (FAS) and public address systems (PAS). OLSEH has installed FAS and PAS across campus. OLSEH maintains FASs and PASs through an external vendor.
f. IISc has a documented Emergency Response Plan. IISc users are expected to be familiar with it. You must know your role and expectations during an emergency. Departments are encouraged to have their own evacuation and emergency response plan that accounts for their specialised hazards.
g. OLSEH has installed safety signage, fire orders, and LED fire exit lights across campus.
h. OLSEH has notified designated assembly points for buildings across campus.
i. OLSEH conducts regular mock drills to train students in emergency evacuation, assembly, use of fire extinguishers and fire hydrants.



Symbol found on fire extinguishers and what they mean					
Wood, Paper and Textile	✓	✓	✓	✗	✓
Flammable Liquids	✗	✓	✓	✓	✗
Flammable Gases	✗	✗	✓	✗	✗
Electrical Contact	✗	✗	✓	✓	✗
Cooking Oils and Fats	✗	✗	✗	✗	✓

Fig 6.4 Know your extinguisher

CHAPTER 7

Laser & Radiation Safety

Lasers can cause severe, often irreparable, eye damage. Radiation hazards commonly come from radioactive sources, high-energy ionizing radiations like X-rays, and high magnetic fields. Many of these cause irreparable long-term health issues.

7.1

Laser Safety

a. A laser produces an intense, highly directional beam of light. High-power lasers can cause damage to the eyes and skin, and in extreme cases cause blindness (Figure 7.1).
b. In general, we should never come in the way of laser light. Do not stare at a laser, ever.

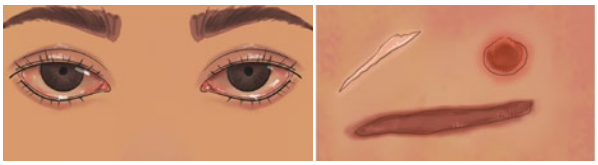


Fig 7.1 Damage caused to eyes (retina and cornea) and skin by highpower lasers.

7.1.1 Hazard

a. Eyes are essentially transducers for visible light. Light entering the cornea has an aperture of 7 mm when fully dilated. This light is focused to a 10 to 20 µm point on the retina, a concentration of 10^5. At high irradiance, the concentrated energy causes local heating that burns the pigment epithelium and the adjacent light-sensitive rods and cones. This results in temporary or permanent loss of vision.
b. Table 7.1 below shows the calculated distances at which lasers with typical beam spreads are dangerous to the eyes. These are guidelines. Lasers can be hazardous even beyond these distances.
c. Damage to the eye also depends on the laser wavelength (Figure 7.2). Wavelengths within 380–1400 nm go through the cornea and are absorbed in the retina. Wavelengths shorter than 380 and longer than 1400 nm are absorbed in the cornea or lens. Either can cause significant damage to the eye and is extremely painful.

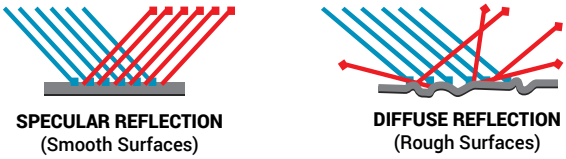


Fig 7.2 Specular vs Diffuse reflection of laser beam

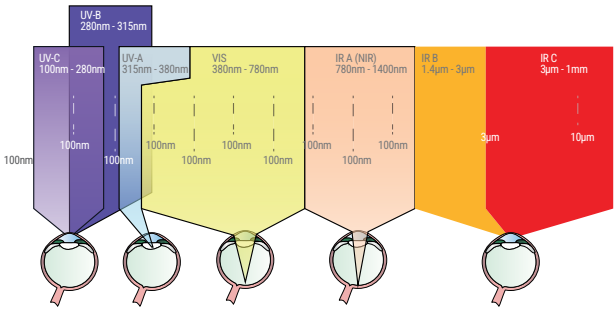


Fig 7.3 Effect of laser wavelength on various parts of the eyes. Retina damage is irreparable. Cornea and lens damage is extremely painful.

d. Damage to the retina is usually irreparable, so 380– 1400 nm lasers are more dangerous.
e. However, given the lack of aversion, longer wavelength lasers (>1400 nm) must be taken just as seriously.
f. UV light is dangerous at all powers because UV causes photochemical damage in addition to thermal damage. This damage is accumulative even at very low powers (See Section 7.1.3 on MPE & Figure 7.2)
g. Pulsed lasers deliver all the power in very short pulses (10 us to less than fs). So, Pulsed lasers can have extremely high peak power but a low average power. Pulsed lasers are characterised by Energy density (J/cm^2).
h. A pulsed laser can also have a high pulse repetition rate (several MHz), so thousands of pulses are delivered in the 0.25 s it takes for you to blink.
i. The biological effect of irradiance on skin can vary from mild erythema to severe blisters. At very high irradiance, pigmentation, ulceration, and scarring of the skin and damage to underlying organs may occur.
j. Exposure can also be varied. Worst is a direct hit from the primary laser beam. However, reflections off a shiny surface can be just as bad. Reflections off a rough surface are less severe but also complex to detect, hence dangerous (Figure 7.3).

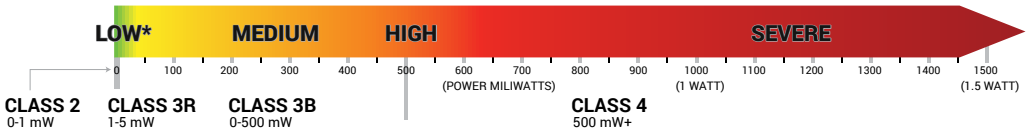


Fig 7.4 Laser classifications based on power levels

Table 7.1 ANSI/IEC Laser Safety Standards

Class	Output Power	Hazard	Engineering control	Training	Regular Eye Test
1		Typically, when a laser is not accessible. Non-hazardous to the eye	Not required	Not required	Not required
1M		Hazardous when collecting optics (e.g., with microscopes)	Not required	Not required	Not required
2	0–1 mW	Hazardous only when the person overcomes aversion	Not required	Not required	Not required
2M		Hazardous with collecting optics and/or Class 2 hazard	Not required	Not required	Not required
3R	1–5 mW	Hazardous when the person overcomes the aversion response	Yes	Not required	Not required
3B	5–500 mW	Direct beam eye hazard. No serious injury from diffuse reflection to the eye or skin	Required	Required	Suggested
4	>500 mW	Hazard to the eye and skin from direct, specular, or diffuse reflection. Fire hazard	Required	Required	Suggested

Table 7.2: Example calculations of Typical Optical Power for various laser classes and the distance over which eye/ skin damage or fire hazards can occur

Laser	Eye hazard distance or nominal ocular hazard distance (NOHD) up to which beam power is >2.5 mW/cm^2	Flash blindness distance up to which the beam power is > 100 µW/cm^2	Skin burn distance	Fire hazard distance
Class 2 0.99 mW, 532 nm	14 m	67 m	0.9 m	0.6 m
Class 3R 4.99 mW, 532 nm	32 m	149 m	2.1 m	1.4 m
Class 3B 499 mW, 532 nm	158 m	747 m	10.5m	7.0 m
Class 4 5 W, 532 nm	250 m	1182 m	16.6 m	11m

7.1.2 Laser Classification

a. Lasers can be classified based on power, wavelength, and mode.
b. Visible CW lasers (400–700 nm) are categorized into classes based on their power. Modern ANSI/ IEC classification is preferred (see table below). Class 1 lasers have the lowest hazard, and Class 4 lasers have the highest. Exposure time is expected to be < 0.25 s. The system assumes that the user will have an aversive reflex to prevent longer exposures.
c. Non-visible IR lasers (> 700 nm) do not generate any aversion reflex. This significantly increases the possibility of more prolonged exposure, which is very dangerous. Even at lower powers, there is a significant risk of losing eyesight.
d. UV lasers (180 to 400 nm) are another class of non-visible lasers. Due to their very high photon energy, UV lasers are dangerous at all powers. The exposure limits are lower than those of other lasers (See section on MPE)

7.1.3 Maximum Permissible Exposure

a. The safe levels for the eyes are given by the Maximum Permissible Exposure (MPE). MPE is usually about 10% of the dose that has a 50% chance of creating damage, under worst-case conditions.
b. MPE depends on wavelength and exposure duration. IEC-60825-1 and ANSI Z136.1 standards include methods of calculating MPE.
c. The MPE as per IEC 60825 is given in Table 7.4. For most CW lasers, an MPE of 1 mW/cm^2 is reasonable. The only exception is deep-UV, whose MPE is lower for exposures beyond 1 second.
d. MPE calculations for pulsed lasers are much more complex. Standards like ANSI provide tables for calculating MPE. Details are beyond the scope of this document.
e. MPE values can also be calculated for skin exposure.

7.1.4 PPE: Safety Eyewear



Fig 7.5 Laser Safety Goggle with Safety Rating

a. Appropriate eye protection must be worn with Class 3 and above lasers. Eye protection is also required for any non-visible laser.

b. Always wear laser safety glasses whenever lasers are in the same room, irrespective of whether you are using that laser or not.
c. Laser safety eyewear reduces the intensity of the laser beam. The amount of attenuation depends on the class and wavelength of the laser.
d. Safety eyewear must follow the ANSI Z136, IEC 60825, or EN 207. These standards correlate safety with transmittance. Transmittance (T) is specified by optical density. Higher OD is higher protection.
e. Calculate the intensity of the CW laser (E_{inc}) in mW/cm^2. If the beam diameter is more than 7 mm, use the eye aperture area (0.385 cm^2) to calculate intensity. Otherwise, use beam diameter to estimate intensity.

Peak Power	Min OD
10 mW/cm²	1
10^3 mW/cm²	3
10^6 mW/cm²	6

f. Check the MPE from Table 7.4. For most wavelengths, an MPE of 1 mW/cm^2 is reasonable.
g. Calculate the required minimum OD for eyewear.

$$\mathrm{OD} > \log_{10}\left(\frac{E_{\mathrm{inc}}}{1\mathrm{mW/cm^2}}\right)$$

h. For pulsed and mode-locked lasers, use the European standard, EN207 (See Table 7.3). EN207 accounts for mode, power, and pulse duration.
i. EN207 establishes an Lb-Rating. Lbn is like OD. Higher Lbn, means more protection.
j. The correct choice of laser safety is nuanced. Always discuss the need with your PI.

7.1.5 PPE: Clothing

a. Diffused reflection from Class 4 lasers is hazardous to the skin and eyes. To minimise exposure, wear full-sleeved clothing. This can be aprons or lab coats. Full shirts and trousers made of tightly woven fabrics can also be used.
b. For class 4 lasers, sun screens are a good idea.

7.1.6 Other Engineering Controls

a. The following engineering controls are needed for class 4 and non-visible lasers. They are also good practice for class 3 lasers.
b. The laser must be confined to an optical table or an enclosed beam path.
c. The optical table should have laser safety curtains, laser barriers, and blackout materials to prevent light from leaving the experimental setup area.
d. Carry out experiments on an optical table such that all laser beams travel horizontally.
e. A warning light must be installed at the entrance of the door.
f. Safety eyewear must be stored outside the room or in a partition housing the laser.

7.1.7 Best Practice

a. Wear PPE at times, irrespective of the laser condition.
b. Always check if the laser safety eyewear is adequate for the laser before use.
c. Never look directly at the laser beam. Even if you are wearing PPE.
d. For Class 2 lasers or above, post appropriate warning signs and labels near the laser and rooms.
e. Rooms with Class 3 lasers or above must have all windows and doorways blacked out so that the laser never leaks out.
f. Class 3 lasers and above must be installed in a dedicated workspace, with wall-to-floor partitions. No safety eyewear works at all wavelengths, so simultaneously using lasers with different wavelengths in the same area is dangerous.
g. Do not use a class 3 or above laser with telescopes, microscopes, or alignment devices without approval from the PI. This can increase the irradiance and hence the hazard.
h. Turn off the laser before making any changes to the optics in the beam path.
i. Do not place laser beams at eye level.
j. Do not allow objects that cause unexpected reflections in the beam path, e.g., metallic buttons, screw heads, watches, or jewellery.

k. Be aware that lenses and other optical devices may reflect a portion of the incident beam from the front or rear surface.
l. Operate a laser at the minimum power necessary for any operation.
m. Exposure to laser radiation must be kept below the MPE under all conditions of operation or maintenance.
n. The general illumination level of the lab should be high so that the pupils can read it, reducing the hazard.
o. Removal of protective housing or system modification can increase a laser's classification. Beware!!

Table 7.3 Laser Mode, Energy Symbol, and Pulse Duration Classification

Laser Mode	Energy Symbol	Pulse Duration
Continuous Wave (CW)	D	> 0.25 seconds
Pulsed Mode	I	> 1 micro second – 0.25 s
Giant Pulsed Mode	R	1 nano second – 1 μs
Mode Locked	M	< 1 nano second

Table 7.4 Laser Optical Density (OD) Requirements by Wavelength, Mode, And Energy

Wavelength	Laser Mode	Max Power Density (P) or Max Energy Density (E)	Min LBn
180–315 nm	D	1×10^{-7} W/cm²	$\log_{10}(P)+3$
	I & R	3×10^{-3} J/cm²	$\log_{10}(E/3)-1$
	M	$3\times10^{+6}$ W/cm²	$\log_{10}(P)-10$
315 - 1400 nm	D	1×10^{-3} W/cm²	$\log_{10}(P)-1$
	I & R	5×10^{-7} J/cm²	$\log_{10}(E/5)+3$
	M	1.5×10^{-8} W/cm²	$\log_{10}(E/1.5)+4$
1.40 - 1000 um	D	1×10^{-1} W/cm²	$\log_{10}(P)-3$
	I & R	1×10^{-2} J/cm²	$\log_{10}(E)-2$
	M	$1\times10^{+7}$ W/cm²	$\log_{10}(P)-11$

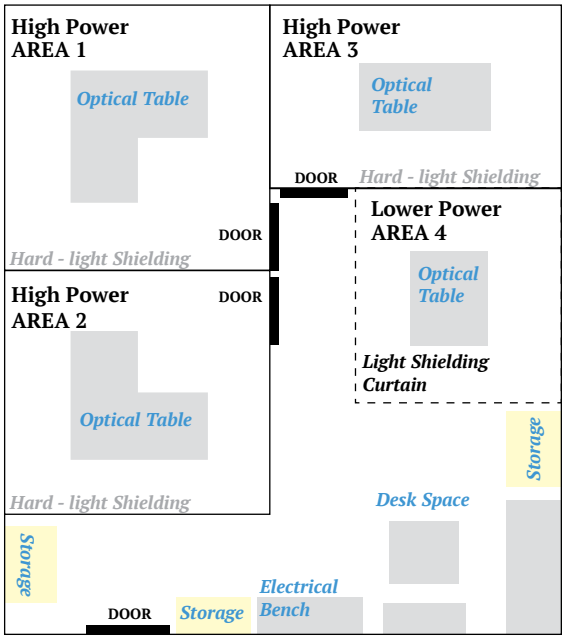


Fig 7.6 Layout of the high-power laser lab at CeNSE, showing separate workspaces. Courtesy Prof. Supradeepa

7.2

Ultraviolet Safety

a. All radiations of wavelengths shorter than 350 nanometers should be considered dangerous.
b. Protective safety eyewear with UV-absorbing lenses should be worn if there is a chance of accidental eye exposure.
c. Skin exposed to intense UV radiation may result in skin damage and should be adequately protected.

7.3

Guidelines of Radiological Safety of Sealed Sources

Radiation can cause painful burns. So, be fully clothed while working under UV radiation. UV lights are often used to sterilize indoor spaces. In such cases, please make sure the room has tinted/plastic windows so that UV light does not escape.

GIC 5000/BI 2000 is a self-contained, dry source storage chamber of Category I, sealed gamma radiation emitting source of high intensity. The gamma radiation-emitting sources are often Caesium or Cobalt 60. Such sources are mainly used for irradiating blood/tissue or even small-sized animals. The exposure rates measured at 1 meter from the accessible surface of the GIC should be within the permissible limit.

7.3.1 Sealed sources (Gamma Irradiation Chambers-GIC 5000 / Blood Irradiator 2000)

a. Be familiar with the basic design, operation, and preventive maintenance of the GIC unit, including procedures for routine operation and handling emergency situations.

Table 7.5 Maximum permissible exposure limits, as per AERB directive no. 01/2011

Occupational Worker	Apprenticeship & Trainee	Public
• an effective dose of 20 mSv/yr running averaged over five years • an effective dose of 30 mSv in any year; • an equivalent dose to the lens of the eye of 150 mSv in a year; • an equivalent dose to the extremities (hands and feet) of 500 mSv in a year • an equivalent dose to the skin of 500 mSv in a year;	• an effective dose of 6 mSv in a year; • an equivalent dose to the lens of the eye of 50 mSv in a year; • an equivalent dose to the extremities (hands and feet) of 150 mSv in a year and • an equivalent dose to the skin of 150 mSv in a year	• an effective dose of 1 mSv in a year; • an equivalent dose to the lens of the eye of 15 mSv in a year; and • an equivalent dose to the skin of 50 mSv in a year.

b. Operate the GIC unit as per the standard operating procedures (SOP) prepared by Radiation Safety Officer (RSO) from the detailed instruction manual provided by the manufacturer/ supplier of the GIC unit.
c. Follow all applicable rules and regulations for the safe operation of the GIC unit.
d. Ensure proper handling and placement of the sample/product inside the sample chamber based on the dose profile of the sample chamber.
e. Maintain a logbook for the use and operation of the unit, including personnel details and details about the samples/ objects under irradiation, dose rate, dose delivered, and time of irradiation.
f. Make proper use of protective equipment, radiation monitors, and personnel monitoring devices as provided.
g. Report to RSO/licensee of any issues related to the safe operation of the GIC, including the circumstances that could adversely affect the safe operation of the GIC unit.
h. Be familiar with area security safeguards such as locks, posted signs, warning lights, and interlock systems.
i. In case a female worker becomes aware of being pregnant, notify the employer, licensee, and RSO so that the working conditions can be modified as necessary.

7.3.2 Decommissioning and Disposal Procedure:

a. Licensee shall obtain prior approval from the Competent Authority for decommissioning, transport, and safe disposal of radioactive material by submitting the application in the prescribed format.
b. Upon obtaining the approval for decommissioning, the licensee should approach the manufacturer/ supplier for decommissioning and transportation of disused sources in the GIC unit.
c. The room housing the GIC can be released for any other use by the institution only after decommissioning of the GIC installation.
d. The transportation of GIC units from the manufacturer/supplier institution to the user institution and vice-versa should be carried out by adhering to the security guidance specified in AERB Safety Guide on 'Security of Radioactive Material during Transport' [AERB/NRF-TS/SG-10, (2008)].
e. Before disposal/transfer, the spent/disused source must be characterized: radionuclide content, activity, history, inventory etc.
f. Integrity of the sealed source must be verified; if the housing is contaminated / damaged or there's risk of leakage/ contamination — special precautions must be taken
g. Sources must be packed, marked, labelled and transported in compliance with AERB transport regulations
h. If not immediately returned, an exclusive safe and secure storage facility (temporary storage) must be provided until transfer/disposal.
i. If the source housing or associated device is contaminated (fixed or non-fixed contamination), then those components must be separated and treated as radioactive waste. Such waste must be disposed of via authorised waste-management routes.
j. Disposal or transfer (return to supplier or to authorised waste manager) requires explicit prior authorisation from AERB.
k. Transfer for disposal abroad (export) also requires permission from AERB, and compliance with both domestic and international transport regulations.

7.3.3 Emergency response plan:

a. The emergency response plan should be as per Rule 33 of the Atomic Energy (Radiation Protection) Rules, 2004, in coordination with the Radiation Safety Officer (RSO), which envisages various emergency scenarios/situations that may be encountered, and action plans for responding to emergencies to mitigate their consequences. To ensure prompt, safe, and coordinated actions during incidents involving sealed radioactive sources, including:
    - Loss or theft of a source

- Suspected or confirmed damage to the sealed source capsule
- Fire, explosion, or natural disasters involving the source
- Accidental exposure to personnel
- Transport accidents involving a source

b. STOP—Warn—Evacuate
- Stop the operation immediately
- Warn all personnel in the area
- Evacuate non-essential persons
- Prevent public entry into the affected area

c. Initial Radiation Survey
- Performed by the Radiation Safety Officer (RSO) using:
- Survey meters (GM detector)
- Dosimeters

d. Establish Controlled Zones
- Hot Zone: High radiation—entry only with RSO authorisation, barricade the area to prevent unauthorized access/entry.

e. Specific Emergency Scenarios & Required Actions

i. Dropped or Damaged Source Capsule
- Do not touch the source
- Evacuate and restrict entry
- Survey to verify if capsule integrity is intact
- If leak suspected → treat as contamination incident, apply wipe tests
- Inform AERB immediately

ii. Fire in Source Storage or Facility
- Use fire extinguishers without approaching the source
- If safe: isolate electricity, close fire doors
- After fire is controlled, RSO performs a radiation survey
- Ensure source is intact and shielding is effective
- Report to AERB

iii. Loss or Theft of Sealed Source
- Notify RSO, employer, local police immediately
- Preserve CCTV, records
- Evacuate & secure the facility
- Inform AERB within 24 hours (immediately for high-activity sources)

iv. Transportation Accident
- Follow instructions in Transport Code
- Secure area, warn public, and prevent ignition sources
- Notify AERB, consignor, and local authorities
- Radiation survey before moving the package

f. Incident Report to AERB (Mandatory) Include:
- Description of incident
- Source type, activity, category
- Personnel doses
- Corrective actions
- Preventive measures

g. Post-Emergency Actions
- Final radiation survey
- Medical evaluation of exposed workers
- Root-cause analysis
- Implementation of corrective & preventive actions
- Submission of detailed report to AERB

7.4

Guidelines of Radiological Safety of Unsealed Sources

Setting up a radiological laboratory at IISc requires a systematic approach based on the Atomic Energy Regulatory Board (AERB) guidelines. The process involves classifying the lab, ensuring proper facilities and equipment, and adhering to strict safety protocols for handling radioactive materials.

7.4.1 Laboratory Classification

First, we must determine the appropriate lab classification based on the specific radionuclides used and the planned activities.

Radionuclides are categorised into four groups based on their radiotoxicity.

a. Group I: Extremely high radiotoxicity, including Po^{210}, Ra^{226}, Pu^{239}, Am^{241} etc.
b. Group II: Highly toxic, like I^{125}, Co^{60}, and Cs^{137} etc.
c. Group III: Medium to low toxicity, like C^{14}, P^{32}, S^{35}, and I^{135} etc.
d. Group IV: Low toxicity, like H^3, C^{14}, P^{32} etc.

7.4.2 Laboratory Type

Based on the Type and quantity of radionuclides being handled, laboratories are classified into three types. The quantity is measured in becquerels (Bq), a unit of radioactivity.

Table 7.5 Laboratory Type Classification by Activity.

Group of Radionuclides	Type I (Low)	Type II (Medium)	Type III (Stringent)
I	< 185 kBq	185 kBq-185 MBq	> 185 MBq
II	< 1.85 MBq	1.85 MBq-1.85 GBq	> 1.85 GBq
III & IV	< 18.5 MBq	18.5 MBq-18.5 GBq	> 18.5 GBq

For example, using normal chemical operations with less than 1.85 MBq of a Group II radionuclide would require a Type III laboratory. However, handling more than 1.85 MBq of the same radionuclide would necessitate a Type II laboratory. You must choose the lab type corresponding to the highest activity and most toxic material you plan to handle. At IISc, we have Type-I at MBU and Type-II at DBG, MCB and BC. Type III lab will need special permission.

7.4.3 Lab Requirements

Once the laboratory type is determined, we must ensure the facility meets the specific requirements for that classification as per AERB (SC/LAB/01, 2016). The following are basic requirements for all labs:

a. Dedicated rooms or partitions with strict and logged access control.
b. Table and floor surfaces that are non-absorbing, smooth, unbroken, and easy to decontaminate. Porous materials like wood or concrete are forbidden.
c. Contamination monitor
d. GM Counter
e. Dedicated storage that is not shared with non-radioactive materials.



Fig 7.7 Requirements of AERB registration and TLD dosimeter

f. PPE: lab coats or aprons, disposable nitrile gloves, closed shoes (no sandals), and safety glasses. Replace with safety glasses with goggles if splashing is possible.

Table 7.6 Additionally, labs must have the following, depending on the Type

	Type I (Low)	Type II (Medium)	Type III (Stringent)
General description	Specialised lab	Specialised lab with exhaust, fume hood, & intrusive monitoring.	Very specialised labs, like a cleanroom or BSL3/4 lab.
Layout	At least two rooms, one for handling materials and one for counting or preparation samples.	Three or more rooms for storage, preparation, and handling	Three or more rooms for storage, preparation, and handling
Surface		Non-absorbent & smooth wall surfaces	Non-absorbent & smooth wall surfaces.
Work-area	Bench or table, but only if gaseous release is not expected	All work inside the fume hood with −50 to −200 Pa relative pressure	All work inside a dedicated glove hood with −200 to -250 Pa relative pressure Outlet connected to exhaust.
Ventilation (air inlet)	Proper ventilation with 6 to 12 air changes per hour	Active AHU with 12 to 15 air changes per hour	Active AHU with 15 to 20 air changes per hour
Exhaust (air outlet) from glove box, hood & storage		1. No air recirculation 2. Dedicated exhaust system discharging air 120-150 cm above the roof of the tallest surrounding building	1. No air recirculation 2. Dedicated exhaust system discharging air 120-150 cm above the roof of the tallest surrounding building 3. Inline HEPA filter & charcoal filter
Negative room pressure	−2.5 to −8 Pa is recommended	-10 to -20 Pa. Pressure cascades from corridor → prep room → main lab → fume hood/ glove box.	-20 to -30 Pa Pressure cascades from corridor (0 Pa) → gowning area (−5 Pa) → main lab (−15 to −20 Pa) → containment room (−25 to −30 Pa).
Storage	Ordinary chemical storage with exhaust	Storage safe made of concrete, steel, or lead for shielding with ex-haust(Thickness of lead cabinet 4-6mm)	Glove box with exhaust
Additional PPE	-	1. Antistatic & disposable overall (e.g. Tyvek) 2. Double disposable gloves. 3. Safety goggles, plus a face shield if splashing is possible. 4. N95 masks 5. Head cover 6. Dedicated shoes or shoe covers	1. Full protective suit (e.g. Tyvek). May need a lead apron. 2. Double gloves that are changed often. 3. Safety goggles, plus a face shield if splashing is possible. 4. P100 respirator or PAPR 5. Head cover 6. Dedicated shoes or shoe covers.
Additional Monitoring	-	Radiation survey meter and contamination monitor.	Radiation survey meter and contamination monitor.

g. Remote handling tongs and remote pipettes.
h. Foot-operated dust bins.
i. The airflow should move from areas of no activity to areas of low, medium, and then high activity
j. Unique personnel dose monitoring (TLD) badges for each user. OLSEH issues these free of charge. You must surrender the old one and get a new badge every quarter.

7.4.4 Operational and Safety Protocols

Finally, the laboratory must follow the strict operational and safety guidelines of AERB to prevent contamination and exposure.

a. General Guidelines
   - Lab Grouping: All rooms for a radioisotope laboratory should preferably be grouped.
   - Facility Usage: Experiments must be conducted in the appropriate approved facilities by AERB. For example, if the limit for a Type I lab is exceeded, the work must be moved to a Type II facility.
   - Segregation: Ensure sufficient area is allocated for each task, including receiving and storing radioisotopes, preparation and application of nuclides, sample counting and measurement, and temporary storage and disposal of radioactive waste.
   - Containment: Fume hoods and glove boxes are mandatory for containing hazardous materials in Type II and III labs, to prevent the spread of radioactivity.
   - Decontamination: All surfaces must be easily decontaminated. Flooring should be non-porous.
   - PPE: PPE should be worn at all times. At the very basic, this means lab coats or aprons, disposable nitrile gloves, closed shoes (no sandals), and safety goggles. Replace with safety glasses with goggles if splashing is possible. Type II and III labs will need more.
   - Personnel: Personnel monitoring badges must be worn to track radiation exposure. People must attend OLSEH offline radiological safety training in every six months. People must attend radiological safety test before handling radiological works.


(Link here https://olseh.iisc.ac.in/assessment/)

   - Shielding: Appropriate shielding (e.g., lead or concrete) is essential for protection against gamma radiation.
   - Training: AERB mandates training for professionals working with radiation sources. OLSEH training attendance is must for all the users of IISc. OLSEH will conduct radiological safety training in every six months.

b. Segregation & Classification of Waste AERB guidelines mandate the segregation of radioactive waste at the point of generation. This means separating waste based on:
   - Physical state: Solid, liquid, or gaseous.
   - Isotope: Isotopes with short half-lives (e.g., P-32, I-131) are separated from those with long half-lives (e.g., C-14, H-3).
   - Activity level: Low-level, intermediate-level, and high-level.
   - Chemical and biological properties: For example, liquid waste containing hazardous chemicals must be managed separately.
   - Waste Minimisation: The AERB emphasises the principle of "as low as reasonably achievable" (ALARA) in waste management, which includes minimising the generation of radioactive waste.

c. Packaging and Containment
   - Approved Containers: Waste must be placed in substantial, secure containers to prevent leakage, spillage, and contamination. The container should be appropriate for the Type and activity of the waste.
   - Labelling: Each container must be clearly and conspicuously labelled with the trefoil symbol (international symbol for radioactivity), the name of the radionuclide, the activity in Becquerel (Bq) or Curie (Ci), and the date of waste generation.

- Shielding: Adequate shielding, such as lead containers or lead foils, should be used. This is particularly important for gamma-emitting isotopes.
- Trained Personnel: Only personnel who have undergone appropriate radiation safety training and are authorised by the RSO can handle and transport radioactive waste.
- Use of Carts and Trays: The containers should be transported on a trolley or in a secondary containment tray to prevent accidental drops and spills, especially for liquid waste.

d. Disposal of radiological waste at IISc:
   - The cans carrying the liquid waste must be filled only to three-fourths of the can's capacity.
   - These cans must be closed tightly (in addition to the lids, stoppers are compulsory) and sealed with tape. Any radioactive spillage resulting from negligence or improper sealing would be brought to the notice of the respective PI and RSO.
   - The radioactivity solid waste must be packed in a cardboard box (BRIT box or Axygen box) and must be well-sealed.
   - The box should have the following details: PI/ lab name, radioisotope name, date of purchase and disposal, volume, and activity.
   - Radioactive waste arising from different isotopes must be compulsorily packed separately and labelled precisely.
   - OLSEH will publish email with waste disposal google form in IISc intra groups for the disposal of radiological wastes one time in a month.
   - In general, OSLEH follows the second Thursday of each month for the disposal of radiological waste.
   - Radiological waste pick up vehicle will attend the requested waste pick-up locations at department.
   - People must bring wastes in LEAD cabinet trolleys with the details of radio isotopes waste in waste disposal forms.
   - OLSEH will transport waste to the designated radiological waste shed at IISc for the storage.
   - People must wear TLD badges while transporting radiological waste to the pickup vehicle or to the waste shed.

e. Emergency Response in Case of Spill or Exposure
   - Immediate Action: Stop, Warn, and Isolate
   - Stop the spill: The first and most critical step is to immediately stop the source of the spill, if it can be done safely without further contamination. This could involve up righting a container or turning off a valve.
   - Stop all work: All personnel in the immediate vicinity should stop what they are doing to assess the situation.
   - Warn others: Alert other individuals about the spill to prevent them from entering or spreading the contamination.
   - Isolate the area: Immediately cordon off the contaminated area with ropes, warning signs, or other barriers. This creates a "controlled area" and prevents unauthorised entry.
   - Notify the Radiation Safety Officer (RSO): The designated RSO of the institute must be notified immediately. The RSO is the key person responsible for responding to a radiological emergency.

f. Personnel Decontamination and Monitoring
   - Check for personal contamination: Anyone who may have been in contact with the spilt material should immediately check their hands, clothes, and other exposed body parts using a contamination monitor.
   - Remove contaminated clothing: If clothing is contaminated, it must be carefully removed and placed in a designated plastic bag or container for radioactive waste. It's crucial to remove clothing in a way that avoids further spreading the contamination.
   - Wash contaminated skin: Contaminated skin should be thoroughly washed with mild soap and water. Care must be taken not to abrade the skin, as this can facilitate the intake of radioactive material.

- Monitor after washing: The affected body areas should be monitored again after cleaning to ensure that contamination has been removed.

g. Spill Cleanup and Decontamination
   - ALARA Principle: The cleanup process must be conducted in line with the "As Low As Reasonably Achievable" (ALARA) principle, which means minimising radiation exposure as much as possible.
   - Personal Protective Equipment (PPE): Personnel involved in the cleanup must wear appropriate PPE, including lab coats, disposable gloves, shoe covers, and, if necessary, respirators or face shields.
   - The spilt liquid should be contained and absorbed using absorbent paper or pads. A moistened absorbent paper can prevent dust from becoming airborne for solid spills.
   - The cleanup should proceed from the perimeter of the spill towards the centre to prevent the spread of contamination.
   - All contaminated items must be placed in a clearly labelled radioactive waste bag or container, including gloves, absorbent paper, and other materials.
   - After the visible spill has been cleaned up, the area must be surveyed meticulously with an appropriate radiation monitor to ensure that all residual contamination has been removed

h. Incident reporting & Investigation
   - In case of any radiological violations, spillage, contamination, modification of radiological practices, or unauthorised access, please inform IISc RSO immediately.
   - A comprehensive report must be prepared using the incident report template
   - The RSO will conduct a detailed investigation of the incident to determine the cause of the spill, the radiation doses received by personnel, and the effectiveness of the response.

CHAPTER 8

Cryogenic Safety

Cryogenic liquids are liquefied gases that are maintained at very low temperatures. Since these liquids are extremely cold and can expand to huge volumes of gases, they are safety hazards.

8.1

Types of Cryogenic Liquids

a. Inert gases: Inert gases do not react chemically. They do not burn or support combustion. Examples are nitrogen, helium, neon, argon, and krypton.
b. Flammable gases: Some cryogenic liquids produce gas that can burn in air. The most common examples are hydrogen, methane, and liquefied natural gas.
c. Oxygen: Many materials considered non-combustible can burn in the presence of liquid oxygen. Organic materials can react explosively with liquid oxygen. Therefore, the hazards and handling precautions of liquid oxygen must be considered separately from those of other cryogenic liquids.



Fig 8.1A Liquid dewar flasks of different sizes



Fig 8.1B Laboratory liquid dewar flask

8.2

Types of Cryogenic Liquid Containers

a. Cryogenic liquids are stored in thermally insulated containers. These cryogenic liquid containers are designed to withstand rapid and extreme temperature changes.
b. Liquid dewar flasks: Liquid dewar flasks are non-pressurised, vacuum-jacketed vessels, somewhat like a Thermos bottle. They should have a loose-fitting cap or plug that prevents air and moisture from entering, yet allows excess pressure to vent. Flasks containing helium, hydrogen, and other low-boiling liquids have an outer liquid nitrogen vessel for insulation (Figure 8.1).
c. Laboratory liquid dewar flasks: Laboratory liquid dewars have wide-mouthed openings and do not have lids or covers. These small containers are primarily used in laboratories for temporary storage.
d. Liquid cylinders: Liquid cylinders are pressurised containers specifically designed for cryogenic liquids. This container has valves for filling and dispensing the cryogens and a pressure-relief valve with a frangible (bursting) disk as backup protection. Never remove/disable the safety valves. Without a safety valve, the tank can explode with disastrous consequences (Figure 8.2).

8.3

Cryogenic Hazards

a. Extreme cold hazard: Cryogens can affect the skin like a thermal burn. Brief exposures can damage delicate tissues, such as the eyes. Prolonged exposure can damage skin. There may be no pain initially, but the injury causes intense pain once frozen tissue thaws. Unprotected skin can stick to metal that is cooled by cryogens. The skin can then tear when pulled away. Even non-metallic materials are dangerous to touch at low temperatures. Prolonged breathing of extremely cold air may damage the lungs. Always handle cryo-liquids with appropriate PPE (Figure 8.3).
b. Asphyxiation hazard: When cryogens form a gas, it is colder and heavier than the ambient. This cold, heavy gas does not disperse, accumulating near the floor. Even if the gas is nontoxic, it displaces air. When there is not enough air or oxygen, asphyxiation and death can occur. Oxygen deficiency is a serious hazard in enclosed or confined spaces. Small amounts of liquid can evaporate into huge volumes of gas. For example, 1 litre of liquid nitrogen vaporises as 695 litres of nitrogen gas at room temperature (21°C).

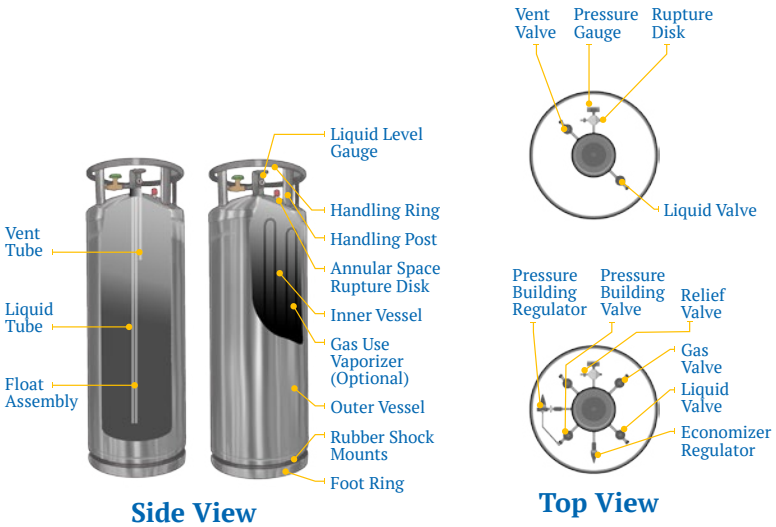


Fig 8.2 (Side and Top) Cross-section of liquid cylinders.

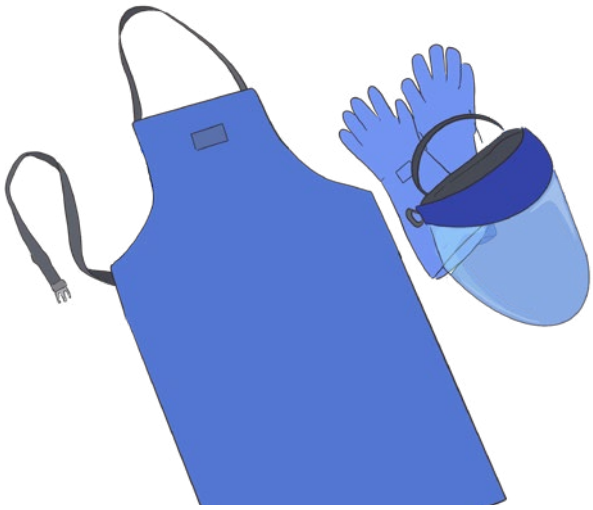


Fig 8.3 Required PPE for handling cryogenic liquids

c. Toxic hazards: Some cryogens can cause specific health effects. For example, liquid carbon monoxide can release large quantities of carbon monoxide gas, which can cause death almost immediately. Refer to the MSDS for information about the toxic hazards of a particular cryogen.
d. Fire hazard: Flammable gases such as hydrogen, methane, liquefied natural gas, and carbon monoxide can burn or explode. Hydrogen is particularly hazardous. It forms flammable mixtures with air over a wide concentration range (4%–75% by volume). It is also very easily ignited.
e. Oxygen-enriched air: Liquid hydrogen and liquid helium are so cold that they can liquify the air they contact. For example, liquid air can condense on a surface cooled by liquid hydrogen or helium. Nitrogen evaporates more rapidly than oxygen from the liquid air. This action leaves behind a liquid air mixture that gives a high oxygen concentration when evaporated. This oxygen-enriched air now presents the same hazards as oxygen.
f. Liquid oxygen hazard: Liquid oxygen contains 4000 times more oxygen by volume than normal air. Materials usually considered non-combustible, such as carbon and stainless steel, cast iron, aluminium, zinc, and Teflon (PTFE), may burn in liquid oxygen. Many organic materials can react explosively, especially if a flammable mixture is produced. Clothing splashed or soaked with liquid oxygen can remain highly flammable for hours.

8.4

First-Aid

a. When inhalation has occurred, the victim (who may be unconscious) should be taken to a well-ventilated area. Rescuers should not put themselves at risk - a contaminated area should not be entered unless considered safe. Breathing apparatus may be required but should only be used by trained personnel.
b. The affected area should be doused with copious quantities of tepid water (40°C) for at least 15 min, and a sterile burn dressing should be applied to protect the injury until the person can be taken to receive hospital treatment. Do not use a direct source of heat, such as a radiator, and give analgesics (e.g., paracetamol, aspirin).
c. Refer to the MSDS for more information.

8.5

Storage

a. Store at room temperature or below 50°C in a well-ventilated place.
b. Ensure appropriate hazard warning signs are displayed (yellow triangle with exclamation symbol and text: 'Liquid nitrogen' should be used when liquid nitrogen is stored in a laboratory).
c. The Government regulates cryogen storage. Cylinders and tanks must be regularly audited and certified.
d. Never store or transport cryogenic liquids in non-rated containers.
e. Never store cryo-liquids above eye level (i.e., above 5 ft).
f. Suppose a safety valve blows up. Please investigate to find the reason for it.
g. Never disable, replace, or weld shut a safety valve. As irritating as they might be, they keep us all safe.

8.6

Transport

a. Only a trolley or a specialised vehicle designed with an open roof and a boundary will be allowed with dewars. Trolley handler or driver should wear cryogen PPE while transporting Liquid N_2.
b. All transportable dewar vessels are fitted with wheels and/or undercarriages. A two-wheeled or four-wheeled handling trolley is available for transporting the 25-litre unpressurized storage containers and must be used for transporting these containers.
c. Filled cryogen dewars may not be transported in closed vehicles. This includes inside passenger cars, minivans, or SUV-type vehicles.
d. Never transport an open container of a cryogenic liquid.
e. Before moving cryogen containers, assess the route for possible obstructions and clutter, lifts, uneven floor, kerbs, stairs, etc.

8.7

Usage

a. Always use cryo-rated gloves, a face shield, and an apron while handling cryo-liquids. Cryo-liquids should not be handled with open-toed shoes.
b. Handle cryo-liquids safely. This means the use of both hands to hold the dewar and duct (Figure 8.4).
c. Use only fitted transfer hoses designed for use with the dewar container. Cracked or damaged insulation on transfer hoses should be replaced. Do not handle transfer hoses with bare hands, as the fitting is not insulated.
d. Remove all metal jewellery from wrists and hands (a spill/splash could freeze the jewellery to your skin).
e. Do not hold the container during filling when transferring from a cryogenic cylinder into a secondary container. It should be placed on the floor or a stable stand, so that the transfer hose rests securely inside the neck of the secondary container.
f. Never fill containers higher than the indicated level.
g. Cover transfer dewars only with the covers supplied by the manufacturer. Never tightly seal a transfer dewar or other containers containing cryogenic liquids.
h. Tongs must be used to withdraw objects immersed in liquid nitrogen.



Fig 8.4 The correct usage with PPE and use of both hands to hold the tank and tube

8.8

Cryogenic Spill

a. Alert others in the area. Evacuate non-essential personnel.
b. Close the lab doors.
c. Don appropriate cryogenic PPE before initiating cleanup.
d. Mark and restrict access to the spill area until resolved.
e. Use commercial spill kits, designed for cryogens.
f. Prevent the spread of cryogen vapours and allow safe evaporation.
g. Ensure the area is well-ventilated to prevent asphyxiation or oxygen enrichment.
h. Dispose contaminated absorbents (oxygen-enriched) in approved containers after complete evaporation.
i. Record all incidents for compliance and safety improvement.

8.8.1 Cryogenic Spill Kit Contents

a. Cryogen-rated insulated gloves (loose-fitting, non-absorbent).
b. Face shield, safety goggles, cryo-apron, and closed shoes (no sandals).
c. Absorbent pads or spill pillows (for liquid oxygen and hydrocarbon cryogens only — not for LN_2 or LHe, where evaporation is the method).
d. Tongs/forceps are used to handle frozen or broken objects.
e. Warning signs: "CRYOGENIC SPILL – DO NOT ENTER."
f. Oxygen monitor (portable).
g. Incident report forms.
h. Minor Spill
   - Applies when spill volume is <1 L. The spill should be confined to benchtop/floor.

- For inert cryogens (e.g., LN_2, LHe, Ar), allow liquid to evaporate naturally in a well-ventilated area. Do not attempt to absorb or mop.
- For liquid oxygen or flammable cryogens (H_2, LNG), keep all ignition sources away. Cover small spills with compatible absorbent material. Allow safe evaporation under supervision.

i. Major Spill
- Applies when spill volume >1 L. Or the release is uncontrolled.
- Do not re-enter until oxygen levels are verified with an O_2 monitor and vapours have fully dissipated.
- Only trained emergency personnel with appropriate PPE may re-enter for inspection or cleanup.
- For LOX or flammable cryogens, fire services must be notified.

j. Equipment Spill
- If the dewar or cylinder is leaking, do not attempt to stop the leak manually.
- Notify the gas supplier/service contractor for safe removal.
- If a safety valve is venting, do not block or tamper. Isolate the area and allow venting to complete.

8.8.2 Spill on Body/Clothing

a. Immediately remove contaminated clothing or jewellery.
b. Flush the affected area with tepid water (40°C) for at least 15 minutes. Do not rub the skin.
c. For eye exposure, flush at an eyewash station for 15 minutes.
d. Do not use dry heat or direct radiant heat sources.
e. Seek immediate medical attention.
f. Report the incident to PI and OLSEH.

Table 8.1: Health Hazards of Cryogenic Liquids

Hazard	Effects	Precautions / Control Measures
Extreme Cold	Frostbite, skin burns, tissue damage, eye injury, lung damage if inhaled	Wear cryo-rated gloves, face shield, lab coat/apron; avoid direct contact; use tongs for immersion
Asphyxiation	Oxygen deficiency leading to dizziness, unconsciousness, or death	Ensure good ventilation; oxygen monitors in confined spaces; avoid working alone with cryogens
Toxicity (specific gases)	Gas release (e.g., CO, NO) causing poisoning or immediate death	Refer to MSDS; use in well-ventilated areas or a fume hood; leak detection systems

Table 8.2: Handling and Transport Hazards of Cryogenic Liquids

Hazard	Effects	Precautions / Control Measures
Pressure build-up	Explosion or vessel rupture	Never seal cryogen containers; ensure safety valves are functional
Oxygen enrichment (LOX, LH_2, LHe)	Increases the fire/explosion risk of normally non-flammable materials	Keep away from flammable/organic materials; avoid contamination of clothing/materials
Fire/Explosion (flammable gases)	Hydrogen/methane vapours ignite easily over a wide range	Eliminate ignition sources; use proper gas detectors; store away from oxidisers
Improper storage height	Spillage or splash injury	Store below eye level (<5 ft); use secure stands/trolleys
Inappropriate transport	Spill, explosion, suffocation risk in a closed vehicle	Use cryogen-rated trolleys; never transport in passenger vehicles; pre-check transport route

CHAPTER 9

High-Pressure & Gas Safety

Pressurised gases and liquids can cause serious injury and damage. High pressure means any fluid that is at a pressure of two bar or higher.

This chapter also covers safety of hazardous gases, which can be Flammable, Toxic and Explosive.

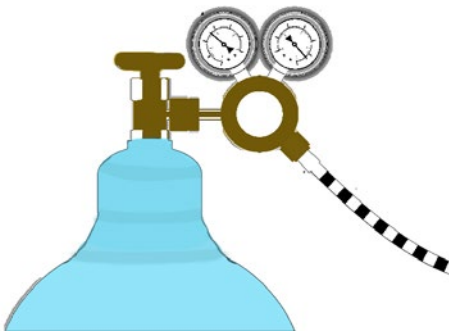


Fig 9.1 Regulator and valve guard

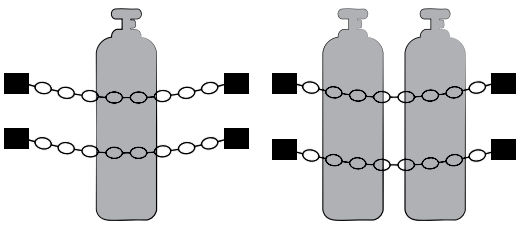


Fig 9.2 Securing cylinders using chains

9.1

General Rules

a. Portable gas cylinders must always be stored vertically, unless specified otherwise by the OEM. This applies to the full life cycle of a cylinder, including transport, storage, use, and disposal.
b. Portable gas cylinders must be harnessed to a solid anchor as per OSHA 29 CFR 1910.253 & 1910.101, or ISO 11625. Cylinder necks can break on impact, which can launch the cylinder like a torpedo, causing massive damage to structures and people.
c. Cylinders > 36 inches high must be harnessed at 1/3rd and 2/3rd height. Smaller cylinders must be chained at ½ height.
d. The harnesses (chain or belts) must be strong enough to withstand a cylinder impact.
e. The anchor must be bolted to a solid building structure, like a wall or floor. Purpose-designed professional racks are acceptable. Carts should only be used for transport or temporary use. They cannot be used for permanent use.
f. "Daisy chaining" (looping a chain around multiple cylinders) is forbidden. Each must be individually secured or in a properly designed rack.
g. All cylinders must always be clearly labelled. This applies to the full life cycle of a cylinder, including transport, storage, use, and disposal.
h. Flammable and oxidising gases must be segregated with atleast 20 feet or 6 meters away from each other.
i. The cylinder must be located away from other hazards. Maintain an exclusion zone around a cylinder as per the standard given below.
j. The cylinders come with a valve guard. This protects the cylinder valve in case the cylinder falls. Please keep it on if the cylinder is not being used.
k. Always install the cylinder with an output pressure gauge and shut off the valve. The former ensures that unsafe pressure is not maintained in the line. The latter is useful in an emergency where the gas supply needs to be turned off.

9.2

Cylinder Transport

a. Cylinders are often poorly handled during transport and delivery. It is the responsibility of the labs to ensure vendors follow the good practices. If they don't respond, please switch to more responsible vendors. Security will report any unsafe behaviour to OLSEH.
b. The cylinders must be stored vertically in the delivery trucks, not lying horizontally on the bed.
c. All cylinders must be tightly restrained to anchors as per OSHA 29 CFR 1910.253 & 1910.101, or ISO 11625.
d. Incompatible gases must be segregated in the delivery truck, e.g. flammable and oxidising gases.
e. A well-designed cylinder cart is the only safe method to move cylinders in corridors and between labs. The cylinders must be strapped to the cart. Never "roll" the cylinders.



Fig 9.3 Don't roll the cylinders

9.3

Cylinder Installation and Uninstallation

a. Most accidents involving gas cylinders happen during installations and uninstallation. Be very careful and alert.
b. Cylinders must be changed by a team of two. Double-checking reduces mistakes.
c. Write down a standard operating procedure (SOP) for cylinder (un)installation with a step-by-step checklist. SOP should be vetted by some authority.
d. Carry a hard copy of the SOP while changing cylinders. Checklists and SOPs are a very good way to make sure you don't forget critical steps.
e. Cylinders must be installed far from other hazards like electrical boxes, windows, drains, and doors. Minimum distances from these are given in Figure 9.4
f. The label on the cylinder must log the date of installation, cylinder number, the contents of the gas, and the contact information of the responsible user.

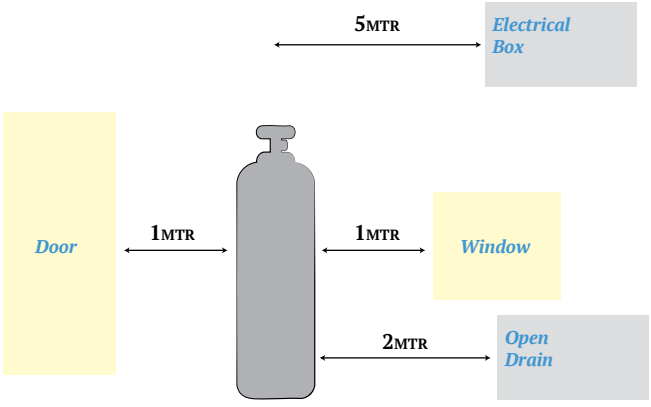


Fig 9.4 Cylinders must be installed far from other hazards like electrical boxes, windows, drains, and doors.

9.4

Hazardous Gases

a. IISc follows NFPA 704 nomenclature to define "hazardous". Any gas with an NFPA rating > 2 in any category is considered hazardous.
b. The higher rating implies that the gas is more dangerous than inert compressed gases due to chemical activity, flammability, explosivity, toxicity, or pyrophoricity. Hazardous gases need additional safeguards.
c. Some examples of hazardous gases are hydrogen, silane, germane, arsine, diborane, phosphine, metal-alkyls, etc.

9.4.1 Reduce Quantity

a. Hazards scale with pressure and quantity. Large cylinders at high pressure can carry up to 10 m^3 of gas. Evaluate if a smaller cylinder with lower pressure will suffice for your experiment. Details will be specific, but as an example, consider the following options for hydrogen.
   - Replace 100% hydrogen with 5% hydrogen diluted in nitrogen (called forming gas). Below 5%, H_2 is intrinsically safe, even at high pressures. So, there is no need for additional safeguards beyond those prescribed for compressed nitrogen. This is the most cost-effective and straightforward solution.
   - Consider purchasing low-pressure cylinders. For example, H_2 gets more dangerous when stored amount exceeds 1% of the laboratory volume at standard pressure. A 40 m^3 lab remains safe from ignition hazard, even in the case of a catastrophic release, if it stores less than 400 litres of H_2. That translates to a 40-litre cylinder at 10 bar.

b. Tabletop H_2 generators are an easy solution for small quantities of H_2. They are intrinsically safe and don't require any special precautions. Prices start at two lakhs.

   For the pressurised Parr reactions (in the room with autoclaves), consider generators that produce higher pressures, e.g.,

   https://thalesnano.com/phoenix-h-genie-platform/

9.5

Safeguard

High-pressure H2 (>4 bar) must be used with proper safeguards. A system must have at least one barrier to prevent a top event and one barrier to mitigate the effect of a top event. Safeguards must also be added to avoid the degradation of a critical barrier. A safety bowtie is a helpful way to visualise this. On the left are preventive barriers, and on the right are mitigation barriers. The analysis is usually the result of a formal HAZID/HAZOP study. OLSEH can help organize these studies for complex systems.

9.6

Mandatory Barriers for >4 Bar

The following basic safety systems are needed for all hazardous gases at pressure (including low-pressure cylinders recommended above)

a. Basic cylinder safety: The Usual requirements for any compressed gas cylinder must be followed, e.g., restraints, labels, etc.
   - As a corollary, cylinders should be transported safely in carts. No rolling.
   - Get cylinders from reputed vendors.

b. Regulators. To step down the pressure for distribution. The output pressure should not be > 8 bar. The use of hazardous gases at higher pressures requires advanced safety features.

c. Flash arrestors: If a flammable gas is being used in an open circuit (at some point, gas vents to air without scrubbing), then inlet lines must have flash arrestors. If flash arrestors are not possible, for example, due to purity requirements, the lines must be closed in a loop with a scrubber at the end.

d. Outlet valves and fittings: All distribution lines should have a high-pressure diaphragm or ball valve made of metal (chemically compatible with the gas). Avoid using low-cost valves from a hardware store. All fittings, tubes, and valves must be made of metal—no insulating materials like plastic/rubber that can cause static.

e. Earthing: Flammable hydrides are highly susceptible to static electricity. All flammable cylinders and lines must be earthed. If the lines use insulating gaskets, such as rubber, then individual sections of the metal line must also be grounded.

f. Access-control. Cylinder change is a critical maneuver. Mistakes can be deadly. Only authorised and trained personnel are allowed to change cyl-

inders. The labs must have some form of access control (e.g., lock, room) to prevent unauthorized changes to cylinders.

g. Log register. A log register must be maintained with the following information.
   - Date of installation with cylinder number; initial quantity of gas in std. litres; cylinder pressure.
   - For every usage, there should be an entry with date, starting cylinder pressure, and volume used in std. litres; final cylinder pressure; & username.
   - Date of removal of the cylinder; final pressure.

h. At a minimum, the gas manifolds must have a purge cross. The purge is used to evacuate residual air during cylinder changeover. Extremely hazardous gases, such as SiH_4, will require more complex manifolds with 5 or 7 valves, which are discussed in the next section.

i. Consider passive flow restrictors that limit flow to a low value, like 1 litre/min. These can be simple orifices with an appropriate diameter.

j. Sensors: All hazardous gases require interlocked sensors. These must be continually active sensors, mounted near the cylinder and usage point. The sensor's output should be connected to a siren and a building fire alarm system. In the event the sensor detects a leak, the departments must evacuate. Handheld sensors can be used to detect manual leaks during delivery and after transportation.

9.7

Additional Barriers for > 8 Bar or NFPA > 3

In cases where pressure is very high (> 8 bar) or if the NFPA rating in any category is 4, additional safety features are required (in addition to those mentioned above). Details may vary, but we must follow the attached checklist. The department is welcome to submit a plan to OLSEH for consideration. The design of all gas distribution systems of such a system must be certified by two faculty members (with suitable expertise), other than the PI, OR approved by OLSEH.

a. Gas-cabinets or gas-banks: High-pressure hazardous cylinders should be stored outdoors in a well-ventilated area whenever possible. The gas can be distributed from the gas bank to the labs using SS pipes. Design the gas-bank well. Gases like H_2 tend to accumulate near the roof. The electrical fitting near the cylinders of flammable gas must be explosion-rated. Alternatively, the cylinder should be installed by a professional gas-cabinet installer. The gas cabinets may be either completely automatic or semi-automatic, shutting off the gas flow from the cylinder in the event of alarms or gas leaks.

b. Cylinder manifold: All high-pressure hazardous gas cylinders must be connected to a 5-valve or 7-valve purge manifold, rated for the gas. Professionally constructed manifolds are commercially available. Don't design your own. Manifolds are often built into professional gas cabinets.

c. Certification for the cylinder. H_2 causes embrittlement of metal. Any H_2 cylinder must be certified by a reputable manufacturer for storage of H_2. This often means regular isostatic testing. In cases where the certificates are not available, the cylinder must be discarded every 5 years of use.

d. Non-arcing tools: For flammable gases, use non-arcing tools for cylinder change or line repair.

e. Gas distribution system: Gas distribution on the manifold must be constructed using fittings rated for H_2. We strongly prefer welded, face-seal fittings (VCR® or equivalent). High-quality Swagelok® or other compression fittings with metal ferrules are also okay, if installed professionally. No plastic tubing. All lines must be He-leak checked after installation or repair.
f. Active fire-fighting equipment: To contain a fire, flammable cylinders must have active fire-fighting systems, e.g., sprinklers. A sprinkler in the vicinity of an H_2 cylinder is mandatory.
g. Documentation:
   - A clearly written SOP for common events like cylinder changes and transportation. OLSEH must approve the SOP. A template is available on request.
   - A list of users who have been trained to change cylinders with dates of their training.
h. Depending on the capacity, autoclaves or other high-pressure equipment themselves might require safety paraphernalia like reinforced walls.

9.8

Storage and Handling

Cylinder and valve integrity may be compromised by improper storage and handling. General storage and handling conditions for all gas cylinders include the following:

a. Cylinders should be stored in well-ventilated areas.
b. Always wear eye protection rated for protection from impact (i.e., ANSI Z87+ rated) while using or handling compressed gases.
c. Cylinders of liquefied gases should be stored upright, unless there are specific directions on the cylinder indicating otherwise. Examples of liquefied gases include, but are not limited to, nitrogen, acetylene, carbon dioxide, ammonia, chlorine, hydrogen sulfide, and hydrogen chloride. Liquified gases also contain higher volumes of gas at room temperature and pressure than the same-sized cylinder of a compressed gas and thus present a greater asphyxiation potential or valve guard
d. Cylinder caps must be in place whenever regulators are not attached.
e. All gas cylinders need to be chained to the wall. The chain must either be at half height or two chains at 1/3 and 2/3 height (Figure 9.2). This ensures that the cylinder stays vertical in the event of cylinder valve failure, preventing it from flying through the walls like a missile.
f. Store cylinders away from corrosive materials (e.g., acids and bases), which can damage the cylinder.
g. Store gas cylinders away from sources of heat.
h. Store empty cylinders away from full cylinders. Ensure that empty cylinders are labeled as such and are returned promptly to the manufacturer.
i. Ensure that gas cylinders are stored such that they do not obstruct means of egress, electrical panels,

eye washes, drench showers, access to hazardous materials, or other items.

j. Never move or use a compressed gas cylinder unless you have been provided with hands-on instruction from your PI or trained and authorized coworkers on how to do so.

k. Don't roll the cylinders; use a trolley with wheels (Figure 9.3).

l. Cylinders must be transported on approved carts, with the strap/ chain in place, and with a cylinder cap. Minimise walking with cylinders. Only walk with cylinders for very short distances to move them from the cart to the final storage location.

m. Regulations govern the storage of compressed gases. Permanent and temporary storage cylinders must be tested and certified at the prescribed schedule.

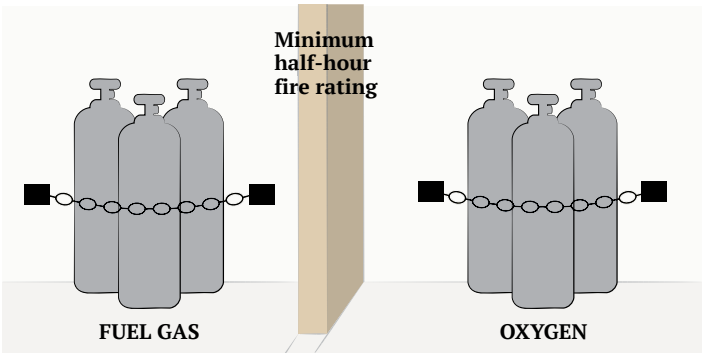


Fig 9.5 For long term storage, segregate cylinders, store them in covered but ventilated cages and keep them chained

9.9

Leaking Cylinder

If a gas cylinder, containing a toxic, flammable, pyrophoric, or corrosive gas, ever develops a leak, then:

a. Evacuate the area and the building.

b. Activate the fire alarm on the way out.

c. Call the security office and the OLSEH office to report the identity of the gas, cylinder size, and location.

d. Lab facilities with hazardous gases are supposed to install automatic sensors for detection and warning of harmful gas leaks. Hand held detectors are strongly recommended.

e. Proper respirators (self-contained breathing apparatus) must be used whenever hazardous gas cylinders are being installed/changed.

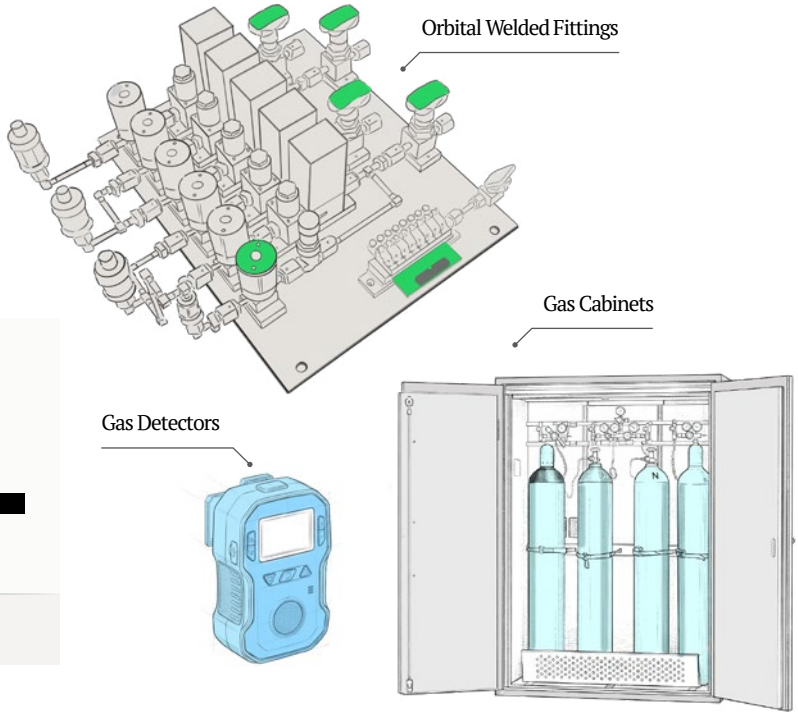


Fig 9.6 Additional requirements for hazardous gas

| 9.10 |

Cylinder Spindles

a. The spindle valves of tanks come in different designs. On the left is an older design (Figure 9.7), where there is a danger of spindle loosening while the valve is being turned on. There are two threads in series. Opening one can open the other. The probability of this is significantly lower in newer spindle valves. Request all labs in charge to do a self-audit of the cylinders in their labs. If they have cylinders with old designs, please change those to more modern ones.
b. The threading of the connection is also a safety feature. Reverse thread connections can be identified visually by a notch inscribed on the circumference of the connecting nut.

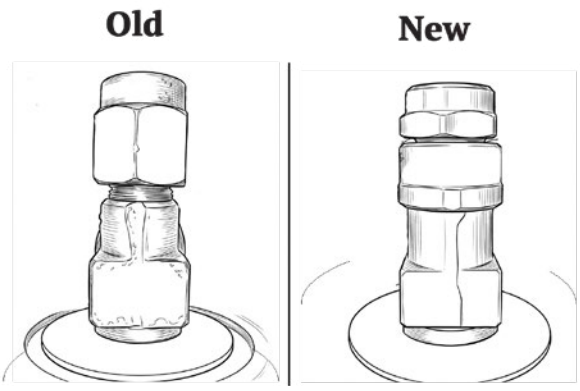


Fig 9.7 Strongly advise all to only accept cylinders with the newer spindle design

| 9.11 |

Protocol for LPG Cylinder in Labs

a. As a rule, the fuel gas loading should not exceed 1 kg per 25 m^2 of floor space in well-ventilated laboratories.
b. The laboratory storage of replacement (disposable) gas cylinders should be kept to a minimum and restricted to less than 1.5 kg. Any sources of ignition are eliminated near the gas cylinder when not being used.
c. Use the cylinders only in well-ventilated areas.
d. The fire load of other hazards present inside labs must be low.
e. Labs should have secondary emergency exits.
f. The minimum distance between flammable and oxygen gas should be 20 feet or 6 meters.
g. Keep the cylinder valves closed when not in use
h. Ensure that the cylinder is always stored upright (vertical) and is not at risk of tipping over.
i. Inspect the cylinder on a regular basis to ensure it is in good condition, free from rust, and housed properly
j. Ensure the cylinder is stored in an area that is adequately ventilated and not susceptible to excessive temperature rise.
k. Store the cylinder in a secure location to protect against falling, damage, being hit by etc.
l. Provide separate storage for LPG away from the oxidizing gases (e.g., oxygen) by at least six meters.
m. Do not store the cylinder near an ignition source, or in locations that could jeopardise escape from the building in the event of a fire.
n. “NO SMOKING” sign board to be placed near the cylinder storage area
o. All kinds of hot works should be restricted in such labs with an LPG cylinder.
p. The flammable gas cylinders should not be placed near the entrance/exit to the lab.

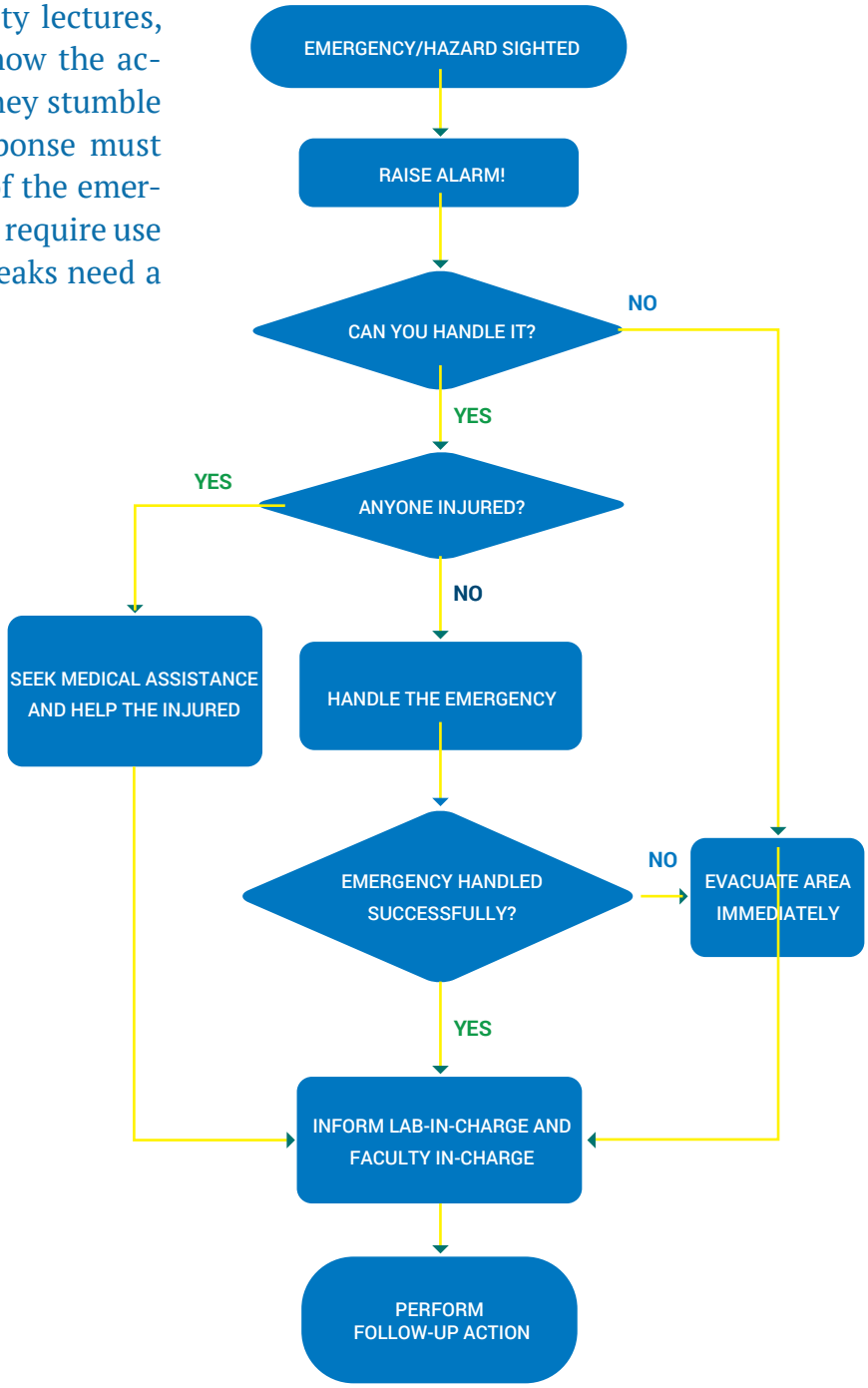
Table 9.1: Summary of High-Pressure Safety

Feature	Low Risk (Inert Gases – N_2, Ar, Air)	Moderate Risk (O_2, CO_2, Small Flammables)	High Risk (H_2, Silane, Arsine, Phosphine, etc.)
Examples	Nitrogen, Argon, compressed air	Oxygen, Carbon dioxide, and small fuel gases	Hydrogen, Silane, Arsine, Diborane, Phosphine
Storage	Keep upright, chain securely, cap on	Same as left + keep away from heat and acids/ bases	Store only in ventilated areas or gas cabinets, never in an open lab
Transport	Use a cylinder cart, keep it vertical, never roll	Same as left + separate different gases during transport	Same as left + ensure vendor follows safe transport rules
Installation	2 people required, follow SOP, wear goggles	Same as left + use regulator & shut-off valve	Same as left + add flash arrestor, purge line, metal fittings, earthing
Quantity Allowed	Usually, there are no strict limits	Avoid oversized cylinders	Must not exceed 1% of lab room volume (e.g., 400 L in a 40 m^3 room)
Safety Devices	Chain, cap, labels	Same as left + regulator pressure < 8 bar	Same as left + leak sensors with alarm, access control, and logbook
Emergency	If a leak: stop work, leave the area, tell the supervisor	Same as left + call OLSEH/security	Same as left + pull fire alarm, only the trained team handles
Training Needed	Basic lab safety training	PI approval + SOP training	Special training, OLSEH approval, and a record of all users

CHAPTER 10

Emergency Response & Evacuation

Using signage and regular safety lectures, all users of a building must know the actions they need to perform if they stumble across an emergency. The response must be contingent on the severity of the emergency. For e.g. smaller fires may require use of fire extinguisher, while gas leaks need a global alarm.



Emergency response decision flowchart

10.1

Emergency Evacuation

All buildings are required to have an emergency evacuation plan that allows all occupants to exit the building, establishes chain of command, demarcates responsibilities, and establishes rules of liaising with external emergency services. The primary responsibility of defining the fire exit plan rests with the Safety Champion of the department that administers the building. The safety champion can take the help from OLSEH to formulate the plan. The emergency plan must follow the following guidelines:

10.1.1 Strategy

a. All buildings must have a method to announce a global emergency that mandates evacuation. This can be a simple a public address system or a manual/automatic fire alarm.
b. All buildings must designate a network of emergency exits, and assembly points such that all occupants of a lab can exit the building and reach the safe assembly point within 2 minutes of a global alarm.
c. The number of these exits and assembly points depends on the size and layout of the building.
d. The location of emergency exits, and assembly points must be clearly shown on signage posted

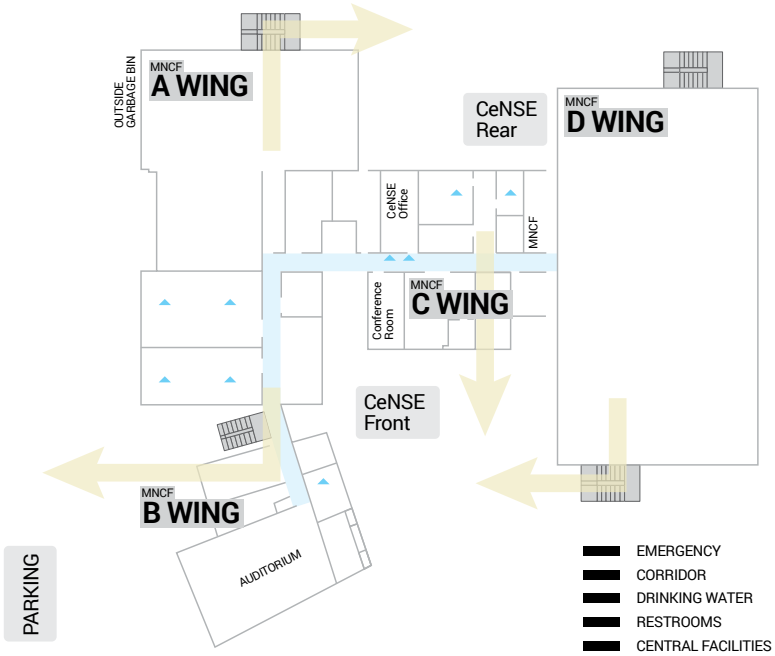


Fig 10.1 An example of a fire evacuation strategy

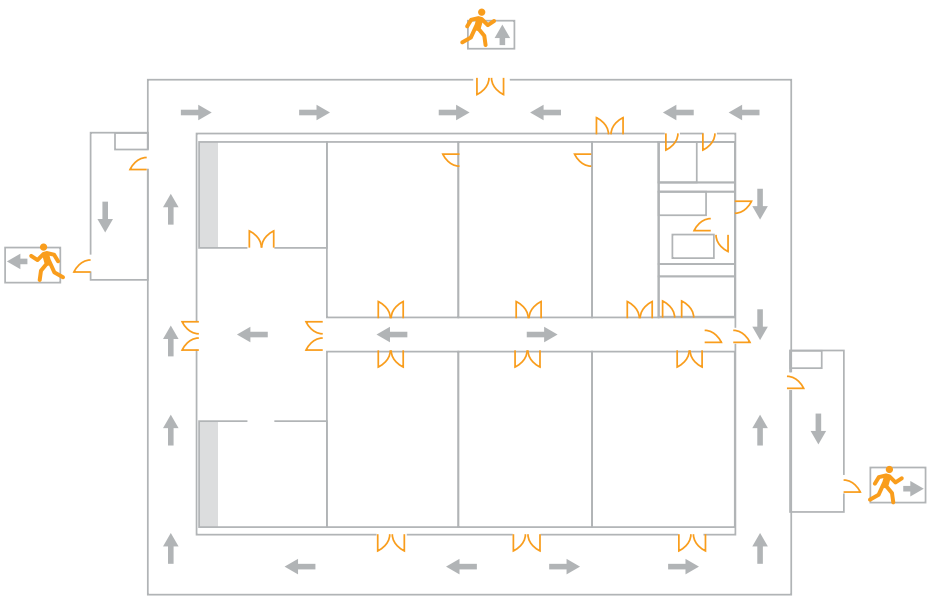


Fig 10.2 Example of an emergency escape route

at strategic locations, e.g. corridors, break-out spaces, lecture halls, assembly points, etc.

e. Assembly points are where occupants assemble during the emergency. Hence the location of these assembly points must be chosen well. The assembly points must be far from the hazards, e.g. electrical yards, gas cylinders, chemical storage, etc. Assembly points cannot be in the path of emergency vehicles.
f. All labs must identify the route to the nearest emergency exit from each lab ("emergency escape route"). This route must be clearly posted inside each lab. See example.
g. The emergency escape routes cannot include elevators. Only stairs can be used during emergencies.
h. During emergency, emergency vehicles such as ambulance and fire trucks must be able to reach the premises. This requires a suitably wide thoroughfare that is always free of obstruction (i.e. no parked vehicles or bikes or storage). Ideally, the emergency vehicles should have 360° access to the building.
i. None of the doors that are part of the emergency evacuation strategy can ever be blocked or physically locked. They can only be latched or electronically locked, such that they can be opened in an emergency by anyone.

10.1.2 Action on hearing a global alarm

All users of a building must know the actions they need to perform if they hear the global evacuation alarm. For most of the occupants, this response will be an evacuation to an assembly point. Some people might have additional responsibilities, e.g. members of the emergency response team (ERT).

10.1.2.1 Emergency response team (ERT)

ERT is a group with the primary responsibility to respond to an emergency. The roles/responsibilities may change with department and associated hazards. At its very basic, ERT is in-charge of ascertaining the validity of the emergency, calling external emergency vehicles, managing the assembly points, liaising with institute and external safety/security teams, and issuing the "all-clear".

a. ERT must be a statutory body in a department, composed of faculty and permanent staff. A part of ERT must be "on-call" 24x7. The composition of ERT must be communicated to the OLSEH by the department Chair. The ERT is assumed to be technically familiar with all the hazards in a department. This might require the ERT to conduct periodic audits in their respective departments.
b. Some multi-storied building may need additional floor-warden who ensures that evacuation orders are being followed in a certain section of the building.
c. Each assembly points must have a designated leader who is in-charge of taking attendance or headcount. This and any pertinent information given by the evacuating public can be escalated to the ERT.
d. ERT is the only one who can issue an "all-clear" after an evacuation. No one can enter the building until ERT has issued the all-clear.
e. ERT is the primary contact for institute and external agencies involved in an emergency. ERT is responsible for calling emergency vehicles (or setup a structure such that this happens automatically). Since they are the only people familiar with all the hazards in a department, the ERT is also expected to liaison with the agencies.

10.2

Chemical Spill Response

Based on the chemicals stored and used in the laboratory, lab in charges must anticipate the types of spills that can occur in their respective laboratories. It is their responsibility to obtain the necessary equipment (spill kits, personal protective equipment, and disinfection materials if biological materials are present in the laboratory) to respond to a spill prior to it happening.

a. If the spill is too large, highly toxic, flammable, aggressive, or just scary, please call emergency response, press global alarm and evacuate. The following compounds are considered very hazardous and should not be cleaned by users: aromatic amines, hydrazine, bromine, organic halides, hexamethylphosphoramide (HMPA), carbon disulfide, cyanides, ethers, nitro compounds and nitriles. Users must also not try to contain gas leaks of flammable, toxic or pyrophoric gases.
b. If and only if you can do so safely, attend to injured or exposed personnel and remove them from exposure.
c. Alert people in the laboratory to evacuate. Alert people in the immediate area of the spill and make sure that you are aware of the hazards associated with the material spilled. If the spilled material is flammable, turn off ignition and heat sources.
d. Clean up the spill. Less experienced user should only clean up minor spills (<50 ml). For larger spills, call help of staff or experienced users.
    - Acids and bases typically need neutralization kits.
    - In case of a mercury spill use mechanical means or a portable pipette vacuum, do not use house vacuum or a vacuum cleaner. Cover small droplets in inaccessible areas with powdered sulfur. Place the residue in a labeled container and dispose it separately.
    - To cleanup alkali metal spills, smother with anhydrous sodium carbonate, calcium carbonate, powdered graphite or sand.
e. While cleaning up the spill, have adequate ventilation (open windows, fume hoods on) and proper protective equipment (minimum: gloves, splash goggles, and apron/lab-coat).

Neutralizing Kits



- For small spills, 10–50 ml
- Experienced student or staff
- Area must be barricaded and labeled

Large Spill Kits



- For large spills, 0.1–50 liters
- Only by trained staff
- Affected lab to be evacuated

Emergency Evacuation



10.3

Fire Response

a. If you see fire, evaluate if you are in immediate danger. If you are, raise alarm and evacuate.
b. If the fire is small, try to contain the fire using a fire extinguisher. If you can't, call ERT. The emergency numbers must be near the landline. Give your name, location, nature of the emergency and telephone number.
    - Once the fire is contained, call the lab in charge and the faculty in charge.
    - Try to assist any injured people around you. See section below on first aid.
c. If you hear the fire alarm, immediately evacuate.
d. During evacuation:
    - If confronted with smoke, keep near the floor. Smoke, heat and toxic gases will normally rise to the ceiling.
    - Do not use elevators, as they might not work during emergency.
    - Using the nearest emergency exit, exit the building.
    - Go to the designated safe assembly point.
    - From the assembly point call the lab in charge and the faculty in charge.
    - Stay at assembly points, until an "all-clear" is issued by the emergency response team.
e. Inform ERT of any hazardous conditions (presence of inflammable/toxic chemicals or gases).

Fire Action


Raise the Alarm


Leave the building by the nearest exit


Report to Assembly Point


Do not return to the building until authorised to do so


Do Not Use Lifts

10.4

First-response (First-aid)

First-aid is a specialist activity so it is hard to be very specific about exactly what to do. Use common sense. Following points are primarily to sensitize you of the possibilities.

10.4.1 General Injury

Do the following and in this order (unless common sense says otherwise):

a. Call emergency response.
b. If an individual is contaminated or exposed to a hazardous material in the laboratory, do what is necessary to protect his/her life without compromising your own. If you can do so safely, determine the nature of the hazardous material and communicate this information to the attending medical personnel.
c. If the person is in contact with a live electrical circuit, do not touch him/her. Disconnect the power first by turning off circuit breakers or by dislocating the live wire with a nonconducting object.
d. Do not move an injured person unless he/she is in further danger. Unnecessary movement can exacerbate injury. Keep the victim warm and awake.
e. Initiate first aid treatment to the victim if trained or qualified to do so. In the case of severe bleeding, place a paper pad (from first-aid kit) or cloth on the cut and apply firm pressure to control the bleeding.
f. Call the lab in charge and faculty in charge.

10.4.2 Burn Injury

Follow the following steps and in this order.

a. Extinguish fire as quickly as possible, with whatever is available. Still it is wise to know that not all methods are equal.
    - Most effective method is to immediately del-

uge the victim with water under a safety shower. Water not only extinguishes the fire but also cools down the body by transporting the heat away, preventing further burns. Of course there should be a water source and you should be in a position to drag the victim to the source.

- Often quickest option is the "stop, drop and roll" drill. Just make sure to put some damp towels on victim to reduce temperature, once the flame is extinguished.
- If water is not available and drop/roll is not practical, blankets, coats, etc. can be used to smother the fire. Remember, try to smother, not fan the flames so they become more intense. Remember even after the flames die down the body continues to suffer damage due to all the trapped heat. So, apply some damp towels, to reduce body temperature.
- In extreme cases, fire extinguishers can be used. However, understand the following:
  i. CO_2 type extinguishers tend to freeze. So, don't focus spray on the same place for 10s of seconds. Try to create a blanket of CO_2 around the person so that the flames die down.
  ii. Extinguishers are designed to be aimed at the base of a fire. They don't work well on surfaces, like human body.
  iii. With foam-type extinguishers, you need to create a blanket around the burning person, which is hard and wastes precious seconds.

b. If there is danger of further injury, move the victim. Else let them be.
c. Call emergency response.
d. Immerse the burned area in very cold or ice water until pain not only is relieved but also does not return when the burned area is removed from the water. If the burn cannot be immersed, apply ice cold compresses.
e. After ice treatment, cover the victim with a blanket to keep him/her warm to prevent hypothermia.
f. If the burns are extensive there is a high probability of victim going into a shock, so try to keep the patient awake and calm.
g. Be careful not to contaminate the burned area. Cover the burned area with sterile gauze or a sheet. Do not apply oily ointments, lotions or cleanser to the burned area.
h. Call the lab in charge and faculty in charge.

10.4.3 Chemical Spill on Body

Symptoms of chemical exposure may include: irritation, burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. If you feel any of these contact a trauma center immediately.

If you come across a victim of chemical exposure:

a. Remove the victim from contact with the chemical as promptly as possible.
b. Affected areas of the skin should be thoroughly flushed with water (at least 15 minutes) by shower. Do not apply neutralizing or buffering agents. During flushing, goggles should be left on the victim until his head and face have been washed.
c. Alkali metals (e.g., lithium, sodium, and potassium) should be rapidly removed with a cloth, paper towel or tweezers before flushing with water. If any metal on the skin ignites on contact with water, immediately deluge it with cold water.
d. Remove the clothing contaminated with chemicals but do not remove clothing that has burned onto the skin.
e. For fluoride acid spills, use liberal amount of calcium gluconate after washing with water to neutralize the fluoride ions. Use way more than what you think is enough.
f. Call emergency response.
g. Call the lab in charge and faculty in charge.

10.4.4 Eye Injury

a. Try to remove the foreign object, if and only if, it is loose and unattached. Best to do this with a wet piece of clean cotton or with clean water.

b. If the particle is on the cornea or is embedded in the eye, do not touch it.
c. For splashes of chemicals in the eye or exposure of the eye to corrosive vapors, remove contact lenses if necessary and flush the eye thoroughly with water from an eye wash fountain for at least 15 minutes. Eyelids should be forcibly held apart so that the entire surface of the eye may be washed. Never apply a neutralizing solution as first aid.
d. Call emergency response. Transfer the victim to a physician or ophthalmologist immediately.
e. Call the lab in charge and faculty in charge.

10.4.5 Ingestion of Chemicals

a. Call emergency response.
b. Call the lab in charge and faculty in charge.
c. Provide the ambulance crew and physician with the chemical name and other relevant information. If possible, send the container, and/or a label along with an MSDS with the victim to the nearby health center.

10.4.6 Inhalation of Chemicals

a. Do not enter the area if you expect oxygen depletion, explosive vapors or toxic gases.
b. Special equipment must be worn by the rescue party. If you don't have access to the equipment, just call emergency response.
c. Remove the victim from the contaminated atmosphere and move into the fresh air as quickly as possible.
d. Call emergency response.
e. Call the lab in charge and faculty in charge.
f. If possible, identify the substance to which the victim was exposed. Provide the ambulance crew and physician with the chemical name and other relevant information. If possible, send the container, and/or a label along with an MSDS with the victim to the nearby health center.

10.4.7 Unknown

In case the victim is unconscious, unresponsive, or unable to respond; and if you cannot ascertain the type of injury, assume the worst. If the lab has toxic gases, assume gas leak. If the lab has hazardous chemicals, assume chemical exposure. If the lab has lasers, assume laser injury. In all cases priority is your own safety.

a. Evaluate if you can safely enter the lab. If not, then just call the emergency response.
b. If you can enter safely, see if you can help the victim.
    - If the victim is in danger of continuous exposure, try to remove him.
    - If the victim is not in danger of more exposure, leave him as is. Unnecessary movement may exacerbate injury.
c. Call the emergency response.
d. Call the lab in charge and faculty in charge.

APPENDICES

11.1 Self-Audit Checklist

Building / Department:	**Room:**
	Date:
Principal Investigator:	
Audit Performed by:	

General instructions:

I. Complete self-audit and send to Department Safety Champion.

II. Mandatory signage can be downloaded from OLSEH website or the Department Office.

III. Personal Protective equipment must always be used when working in the laboratory. Check that students are using them.

IV. Lab in-charge is responsible for laboratory safety. Lab users should be quizzed on safety rules during the audit.

V. Improper chemical segregation is a common issue. Please check the inventory of chemicals to ensure solvents, oxidizers, acids and bases are segregated.

VI. All chemicals must be labelled. Labels can be downloaded from OLSEH website.

VII. All chemical waste must be labelled. Labels can be downloaded from OLSEH website.

VIII. Gas cylinders are also often stored improperly and not tagged. Please check. Tags can be downloaded from OLSEH website

IX. Exit doors, including those which open directly from lab spaces into stairwells, cannot be locked during normal business hours. Security measures are allowed after hours, with the approval of the OLSEH office.

X. Electrical cords that have frayed wires or broken insulation present significant electrical shock and fire hazards. Replace or repair an electrical cord found to be in poor condition.

XI. Cover plates must be installed on all electrical outlets and switches to prevent accidental contact with electrical wires.

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Type	#	Safety Point to check	Yes	No	NA	Remark
General	1	Working telephone near the door				
	2	Emergency contacts list near telephone at eye level				
	3	Hazard sheet is filled and current. The sheets must have been signed in the last 6 months.				
	4	Users are wearing closed toed shoes in the lab. Some labs ask users to take off shoes. In such cases replacement shoes must be provided. No chappals.				
	5	No evidence of food/drinks being brought inside lab. No tea/coffee cups. No lunch boxes.				
	6	The lab should look clean and organized. No accumulated junk, like carboard boxes, trash, etc.				
	7	Has the lab in-charge instituted an orientation program that all new users must go through to get access to the lab?				
	8	At-least one light is connected to UPS?				
Important Note: Minimize storage of materials in laboratory premises. For example, paper goods, plastic containers, materials stored in boxes and empty containers.						
Fire	9	Two feet of unobstructed walking space around labs				
	10	Fire extinguishers (appropriate type) in working order				
	11	Fire extinguishers are stored in proper and visible places				
	12	Equipment that heat up during operation have adequate ventilation				
	13	No exposed electrical wires, broken plugs, broken switches, etc.				

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Type	#	Safety Point to check	Yes	No	NA	Remark
	14	Power strips are of appropriate wattage (for the given load)				
	15	Large equipment connected to earth				
Laser	16	High-power laser (Class 3 and above or invisible) must have warning light outside the door				
	17	Laser safety glasses, if Class 2 laser of above.				
	18	High-power laser (Class 3 and above or invisible lasers) must have a separate partition with floor to wall barrier				
Chemical	19	Chemical containers are labelled properly and contain necessary information. No mystery bottles				
	20	Chemicals are stored in appropriate cupboards. No open shelfs, no wooden (flammable) cupboards. Large amounts of solvents need exhausted cabinets				
	21	All chemical storage must have hazardous stickers (e.g. corrosive, oxidizer, toxic, etc)				
	22	All chemical waste must be clearly labelled. There should be appropriate waste disposal facility for all chemicals stored in the lab. e.g. If you have acids, there must be a way to dispose acids, etc.				
	23	Personal protective eqpt. (Glasses, gloves, aprons, shoes) must be easily accessible, not inside locked cabinets. For liquid hazards need splash goggles, not glasses. For aggressive chemicals, need thick nitrile gloves not thin examination gloves. No latex gloves. Large amounts of chemicals require face shields				

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Type	#	Safety Point to check	Yes	No	NA	Remark
	24	If corrosive chemicals are used, eye sprays must be nearby,				
	25	MSDS of all hazardous chemicals are printed out and stored in a file that is easily accessible				
	26	Acids, bases, oxidizers, and solvents are segregated, either in different cupboards or with secondary containment				
	27	All refrigerators used to store chemicals, must have “No food” sign; no food in any fridge in any lab				
	28	Clearly marking on the dustbins to distinguish lab waste (hazardous) and general waste				
	29	Chemical work can only be done in hoods with proper ventilation				
	30	Sharps must be disposed in hard containers				
	31	Bio waste must be appropriately disposed. Red dustbins for soiled napkins, etc. Blood/cultures can be disposed down the drain but only after hypochlorite treatment (labs should have hypochlorite). Dead bodies must be disposed thru Bio departments.				
High pressure	32	Gas cylinders are properly chained to walls, either at half height or 1/3 + 2/3 height. Cylinders must be stored in a tight formation so that they cannot tip. Carts cannot be used for permanent storage				
	33	Unused or spare gas cylinders must have valve guards				
	34	All cylinders must have tags that identify the contents, status (empty/ in-use/full) and person in-charge.				

APPENDICES

Type	#	Safety Point to check	Yes	No	NA	Remark
	35	All hazardous gas lines must have welded VCR connections; highly dangerous gases must have coaxial connections				
	36	Hazardous gas cylinders need gas cabinets.				
	37	CVD reactors must be connected to functional exhausts.				
	38	Any lab with hazardous gasses must have sensors to detect that gas. The sensor should be functional.				
Cryo	39	All labs with cryo liquids must have cryo-rated personal protective equipment. Everyone needs gloves. Large amounts need face shields and aprons also.				
	40	Cryo cylinders must have safety valves and rupture disks.				
	41	Cryo liquids can only be handled in rated dewars or flasks.				
Electrical hazard	42	Cover plates in place for outlets and switches				
	43	No extension cords used				
	44	Inspect AC filters periodically				
Exits	45	Illuminated signs working				
	46	Paths free from obstructions				
	47	Emergency exits accessible and marked				

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Additional Checklist for Chemical Storage and Handling

a. Generally, light-duty and wooden cabinets should not be used. Cabinets units should be securely anchored to the wall.
b. To avoid potential contamination, food should not be stored in refrigerators or freezers designated for chemical storage.
c. Labelling of cabinets by chemical class (e.g. flammable liquids, acids, oxidizers) is essential if chemical storage is to be segregated to avoid incompatibilities, and to identify storage areas for emergency response personnel.
d. Highly toxic gases, such as fluorine, phosgene, and many semiconductor gases, should be stored in ventilated cabinets made for this purpose. In the event of a leak or fire, the gas cabinet would contain and exhaust the gas, protecting the laboratory worker from exposure.
e. Toxic or flammable substances that can be airborne (e.g. gases, vapours, dusts, fumes or mists) should not be used in unventilated areas. In the absence of adequate ventilation, air contaminants can build up to levels that pose health or flammability hazards.
f. Chemical containers should be clearly labelled with at least a chemical name. The manufacturer's label is best, as it usually contains a great deal of information about health and physical hazards. When a chemical is transferred from the original container, the new container should be labelled, as possible. Small containers may use other means of identification, such as a code or number system referenced to the user's lab notebook.
g. In order to avoid spillage or release of vapors, containers should be closed except when transferring.
h. For optimum performance and containment, a fume hood should have the minimum amount of chemicals or apparatus in it when in use. It is particularly important that the slots or baffles at the back of the hood are unobstructed.
i. Some chemicals may degrade certain container materials. For example, hydrofluoric is incompatible with glass. Inorganic hydroxides are best stored in polyethylene containers. Some organic solvents will soften plastic.
j. Chemicals which may react violently or emit hazardous fumes when mixed should not be stored near each other. Examples include oxidizers and flammables, acids and bases.
k. Corrosive materials can cause severe tissue damage and are particularly injurious to the eye. Storage of corrosive below eye level helps to minimize this risk.
l. Quantities of chemicals in storage should be consistent with the shortterm needs of the lab. Excessive storage should be avoided.
m. When transporting chemicals between rooms or buildings, secondary containers, such as bottle carriers, should be used. In the event the container is dropped, bumped or otherwise breaks, the contents would be contained in the bottle carrier, avoiding a spill. Bottle carriers are available in many stockrooms.
n. Some chemicals, such as ethers or other peroxide-formers, have recommended storage time limits. Chemicals stored beyond their limit date may form explosive peroxides, which may detonate when removing a cap, agitating, dropping, scraping, etc. Upon arrival, these containers should be marked with the date placed in storage and an expiration date based on manufacturer's recommendations. Many manufacturers include an expiration date on the product label.
o. To avoid difficult and potentially costly waste disposal problems, a procedure should be in place to assure all materials are labeled and unneeded chemicals disposed of properly.

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List of gas cylinders and composition (add more rows if necessary)

Chemical Composition	No of cylinders
Total	

List of high-power lasers (add more rows if necessary)

Make	Wavelength	Pulsed or CW	Power of energy per pulse

Other observations/violations/comments:

11.2 No Food Label for Lab Refrigerators



APPENDICES

11.3 Cylinder & Chemical Labels

The individual departments are requested to print and stock them for use.

CYLINDER TAG

NAME OF GAS: _____

RECEIVED BY: _____

DATE: _____

MOBILE NO: _____

CYLINDER NO: _____

GAS HAZARD CLASS: _____

CYLINDER STATUS

TICK THE APPROPRIATE STATUS AND WRITE DATE

STATUS	DATE
IN USE	
EMPTY	

भारतीय विज्ञान संस्थान

IN CASE OF AN EMERGENCY,
CONTACT OLSEH : 080 2293 3199

SEE OTHER SIDE

CYLINDER STORAGE & HANDLING

1. RESTRAIN the cylinder properly when in storage and use
2. STORE the cylinder in a cool, well-ventilated, and fire-resistant area
3. INSTALL the cylinder where it won't be knocked over or damaged by falling objects
4. CLOSE the valve and SECURE the cylinder's caps when it is not in use
5. INSPECT the cylinder for leaks after connecting
6. TRANSPORT the cylinder using a hand truck/trolley designed for the purpose
7. REPORT any leak or damage



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IISc Safety Signage
Cylinder Tag 1.0

CHEMICAL LABEL

DATE _____

NAME _____

DEPARTMENT _____

LABORATORY _____

CHEMICAL (NO ACRONYM INITIALISMS)

_____

_____

_____

SELECT APPROPRIATELY



OXIDIZER



FLAMMABLE



TOXIC



ENVIRONMENT HAZARD



CORROSIVE ACID



CORROSIVE BASE

भारतीय विज्ञान संस्थान

IISc
Bengaluru

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11.4 Chemical Waste Label

The individual departments are requested to print and stock them for use.



11.5 Laboratory Hazard Sheet

a. Make a lab layout using some software and save it as an image file. Insert it in the 'Room floor plan' box.

b. Ensure that you include (in the floor plan)
   - ALL windows and doors
   - Location of wet benches, fume hoods, laser assembly, chemical storage, High- Voltage equipment, compressed cylinders and biological hazards
   - Location of lab telephone and fire extinguishers and preferably light switches

c. Make use of the personal protective equipment table to specify protective gear like 'Nitrile gloves', 'Laser safety glasses -xyz wavelength' etc. Please be specific with the type of protective gear.

d. Use the 'Description of Lab Hazards' column to indicate hazardous substances. Reference symbols have been provided with this template document. Next to the symbol, specify the hazard as accurately as feasible. Eg: Laser- Class 4; Compressed cylinder-Silane; Acids - HF acid etc.

e. Prepare a new document once in 6 months or every time you make major changes such as shifting of equipment or addition of hazards in your lab.

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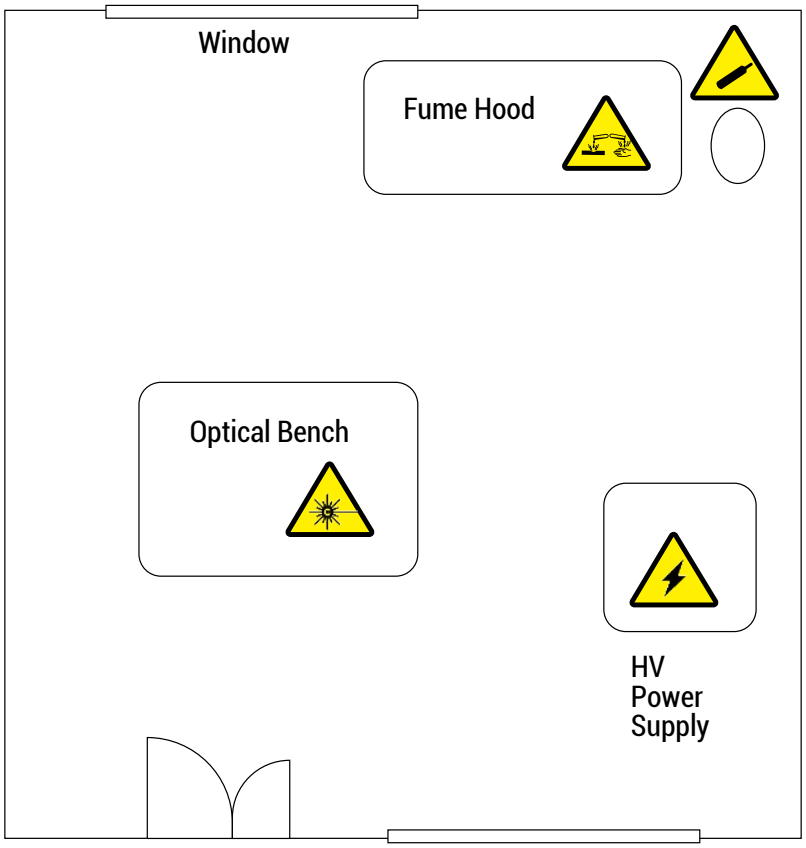
Department CeNSE
Room No SF-XY
Lab Name: XYZ Lab

Review & Initials (every 6 months)

Date				
Initials				

Emergency Contact	Name	Office	Telephone
Safety In-charge 1	Student name 1	SF-XY	Mobile. No.
Safety In-charge 2	Student name 2	FF-XY	Mobile. No.
Faculty	Faculty Name	TF-XY	Mobile. No.

Room Floor Plan:



Description of Hazards	
	Nitrogen cylinder
	Acids in fume hood
	Class 3B He-Ne Laser
	HV power supply equipment

Reference Symbols of Hazards

 Compressed gas	 Flammable	 Toxic	 Corrosive
 Laser	 High voltage	 Radioactive	 Bio-hazard

Protective Equipment	
1	Laser safety glasses 632.8 nm
2	Nitrile gloves
3	Lab shoes
4	
5	

APPENDICES

11.6 Safety Policy

The Indian Institute of Science (IISc) is committed to the health and safety of everybody on both its campuses. The purpose of this safety policy is to establish the responsibility of the IISc's various stakeholders towards this goal. This policy applies to all the IISc's activities; including research, teaching, incubation, and external projects. Further, this policy applies to all the employees, students, visitors, and contract workers of the IISc.

The policy is based on the following Directive Principles:

a. Safety is paramount: The safety of everyone on the IISc's premises is the primary concern. All activities, including research and teaching, must be conducted without compromising safety.
   Accountability: Any person having access to any equipment or material housed in the Institute campus(es) must ensure their and others' adherence to the highest standards of safety besides taking personal responsibility for his/her actions and omissions.
b. Trust but also verify: The Institute recognizes that, as a diverse research campus with more than 40 departments within which a variety of research is being conducted, there is a diversity of hazards and attendant risks. The people responsible for setting up facilities and guiding experiments are expected to be aware of the attendant hazards and risks, and are entrusted with taking necessary safety precautions. The primary role of the Safety Committee is to set safety policies while the role of the Office of Laboratory Safety and Environmental Health (OLSEH) is to implement these policies and monitor compliance. The Institute requires its departments to implement its safety policies in both letter and spirit and reserves the right to verify compliance.

1. Definitions

'*Institute*' refers to the Indian Institute of Science and includes all its extended campuses.

'*Laboratory*' refers to a room or space or field used for research, teaching, measurement, or operations. Often laboratories are fraught with chemical, radiation, biological, radiological or other hazards. For the purposes of this policy, the term also includes the pathways along which material is carried from one laboratory to another, storage areas, and preparatory spaces.

The '*Office of Laboratory Safety and Environmental Health (OLSEH)*' is an office approved by the Council consisting of Environment Health and Safety (EHS) Officers. Its responsibility is to implement Safety Policies.

'*Safety Committee*' is a Committee consisting of faculty members/staff nominated by the Director to oversee and supervise OLSEH and to formulate Safety Policies for the Institute.

'*Department Safety Champion*' is a designated permanent staff of sufficient authority appointed by the Department Chair (or Centre Chair) to oversee safety in a Department/Centre. Every Department/Centre must have a Safety Champion.

'*Employee*' includes any person employed on the Institute's premises, either directly or through an agent. It includes anyone working on the premises, whether on remuneration, on a stipend, or voluntarily. It includes temporary and/or contract employees, whose terms of employment are expressed or implied. It includes faculty members, whether tenured or on contract, contract workers, post-doctoral scholars, research associates, probationers, project staff, trainees, and interns.

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'*Principal Investigator' or PI*, is an Employee, often a faculty member or scientific staff member, under whose supervision an experiment or any other activity is being undertaken in a laboratory.

'*Users*' includes every person using the laboratory, equipment, research infrastructure and other facilities on the Institute's premises. Most often, these are employees and students. Users can also be short-term and long-term visitors, with the term applying to foreign exchange students, visiting faculty, collaborators, interns, parent/sponsor institutions, employees of companies, and individuals who temporarily access facilities at the Institute under any arrangement.

'*Contractor*' is an entity or person who renders services, provides work, or supplies contract labour to the Institute. This includes the tiers of sub-contractors who may be employed by the contractor.

'*Incident Report'* is a written account of any emergency evacuation, emergency alarm trigger, injury, or accident that occurs in a Department/Centre. Incident Reports must contain a description of the event, a preliminary investigation into the cause, the prima-facie cause, and recommendations to prevent such incidents in the future.

'*Emergency Response Plan*' a clear and sequential plan that prescribes the actions and actors during an emergency. The plan is drafted by each Department Safety Champion in consultation with OLSEH.

'*Emergency Response Team*' is a team drafted by the Department Safety Champion and tasked with supervising an emergency in that Department/Centre.

2. "Safety Rules" means the rules laid down by OLSEH or the IISc Safety Committee that must be followed by all "Users". These rules will be listed on the OLSEH website and are subject to revision from time to time. All users must abide by the Safety Policy and Safety Rules and will be responsible for their actions/omissions.

The IISc Safety Committee will consist of faculty, staff, and other personnel as per the relevant norms. The primary role of this committee is to:

a. Review the IISc's Safety Policy from time to time and suggest modifications if any are required.
b. Oversee the activities of OLSEH with respect to the effective implementation of safety policies and advise them from time to time about relevant matters.

3. Office of Laboratory Safety and Environmental Health (OLSEH)

The Institute has established the Office of Laboratory Safety and Environmental Health (OLSEH) to be the primary body responsible for the effective implementation of workplace, environmental, and laboratory safety across the Institute. OLSEH shall report to the Institute Safety Committee. OLSEH will comprise EHS Officers and Senior Personnel. OLSEH will:

a. Conduct periodic risk assessment of all activities, equipment, buildings, policies, procedures, training, and manuals across the institute. These include but are not limited to, research activities; department buildings; and

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student housing; contractor and vendor regulations; and waste and effluent treatment.

b. Take suo moto notice of any safety issue and investigate.
c. Bring to the notice of the Safety Committee, in the form of a report, any hazards observed during assessments or investigations along with recommendations about how to reduce, eliminate and contain said hazards.
d. Provide recommendations on safety policies and actions to the Safety Committee. The recommendations can include, but are not limited to, such matters as rules for personal protective gear, standard operation procedures, waste disposal, storage, emergency response, and incident reporting. In extreme cases of non-compliance (as outlined in this Policy), OLSEH can recommend the closure of laboratories/facilities. OLSEH can recommend the scrapping of faulty or obsolete equipment at the request of the PI.
e. Conduct scheduled and spot audits to ensure that the rules of the Safety Policy prescribed by the Safety Committee are being followed in both letter and spirit across the Institute. To conduct these audits, OLSEH has a right to demand complete and unfettered access to all spaces across the Institute.
f. Inform the Safety Committee of any breach of any prescribed Safety Policy or Safety Rules by any User on the Institute's campuses.
g. Periodically review the Institute's Safety Policy and submit any proposed changes to the Safety Committee for approval. Once approved, OLSEH will inform all stakeholders of the changes made to the policy. This must be done within a reasonable amount of time.
h. Implement the directions of the IISc Safety Committee. This may include matters related to technical advice, the implementation of policies, the conducting of investigations, the procurement of information, and follow-up on action items.
i. Ensure that the Institute has all the required statutory approvals it needs from the state and central governments and other regulatory agencies.
j. Assist the PI in obtaining required equipment- or facility-specific statutory approvals from the state and central governments and other regulatory agencies.
k. Serve as the Institute's primary point of contact with all regulatory agencies and governmental departments.
l. Facilitate any external safety audits mandated by regulatory agencies or appointed by the Safety Committee from time to time.
m. Solicit the Safety Committee for funds to improve the safety infrastructure in the institute.
n. Serve as the primary source of contact for Department Safety Champions (on behalf of Safety Committee).
o. Compile the biannual self-audit reports from Safety Champions of individual departments.
p. Maintain a list of Department Safety Champions, along with their emergency contacts.
q. Maintain a record of all safety incident reports generated by the Department Safety Champions.
r. Serve notices to Users/PIs in case of violations of this Policy.
s. Coordinate with campus security, the Health Centre, and the Centre for Campus Management & Development (CCMD) to provide the support necessary for ensuring safety within the Institute's campuses.

4. Department Safety Champion

Each department or centre shall have a designated Safety Champion, who must be an Employee of the Institute and part of the cadre of faculty and scientific staff with sufficient authority. The Safety Champion will be appointed by the department Chair and OLSEH will be informed of the appointment. The Safety Champion will:

a. Be the primary point of contact at a Department/Centre for the Safety Committee and OLSEH.

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b. Be responsible for identifying and informing OLSEH about any unrecognized hazards in the department.
c. Maintain a list of Principal Investigators for all laboratories, along with their emergency contacts.
d. Maintain records of the biannual safety-audits submitted by each Principal Investigator and compile these biannual self-audits into a report to be submitted to the OLSEH every six months.
e. Conduct investigation into any safety complaint from users and, if necessary, escalate the issue to the IISc Safety Committee and OLSEH.
f. Generate and maintain records of Safety Incident Reports. A copy of these must be sent to OLSEH and shared with the department's members.
g. Establish an Emergency Response Plan for the department as per the norms set out by the Safety Committee. This plan may include details about fire prevention, fire alarms, emergency evacuation, and assembly points.
h. Educate the department community about the Emergency Plan in a mandatory safety session and through a surprise emergency drill, to be organized at least once every year.
i. Establish an emergency response team responsible for overseeing any emergency response. A subset of the ERT must be on call 24x7 to respond to an emergency. The ERT must ensure complete evacuation, offer technical advice to first responders, inform OLSEH, inform the Security Officer, call the Emergency vehicle(s), and manage the assembly points. The ERT is expected to understand the safety hazards present in the Department. The ERT is also the only body with the authority to declare an "all-clear".

5. Principal Investigator

All laboratories must have a supervising '*Principal Investigator*' *or PI*. Typically, this will be a faculty member, scientific officer, or senior project staff member. The PI is entrusted with the safety and well-being of all Users and Contractors in their laboratory. The PI will:

a. Be responsible for implementing the safety policies prescribed by OLSEH in their laboratory. Any sought exceptions must be approved by OLSEH.
b. Be responsible for arranging funds to implement the safety policies prescribed by OLSEH. This includes, but is not limited to, funds for personal protective equipment, safety detectors, storage cabinets, fume hoods, gas cabinets, signage, first aid boxes, and fire exits.
c. Appoint a laboratory safety monitor. The monitor could be a senior research student, project staff member or a scientific/technical staff member.
d. Ensure the prominent display of the laboratory plan that lists hazards and entry/exits using the format specified by OLSEH.
e. Develop well-documented safety protocols for non-standard equipment/facilities and ensure all users are trained in these protocols.
f. Respond to any request for safety infrastructure or complaints made by the Users in their laboratory.
g. Provide a structure to appropriately train Users of their laboratory in order to manage possible laboratory hazards. The structure must be comprehensive and designed with a 'reasonable' User in mind.
h. Monitor the entry of personnel into their labs so that only people with appropriate safety training are exposed to lab hazards. Conversely, people who cannot have such training must be excluded from labs.
i. Conduct a biannual safety audit of their laboratory. The self-audit should be comprehensive and prepared in the format prescribed by OLSEH.
j. Submit the following statement to the Registrar for all new projects:

APPENDICES

"The risk assessment for these planned activities has been done. Infrastructure to conduct the activity safely either exists in the lab or is built into the funding structure of the current proposal."

6. Users

All Users will:

a. Be personally responsible for their own safety.
b. Follow the Safety Rules prescribed by the Safety Committee and/or PI.
c. Undergo training in laboratory protocols and emergency responses
d. Learn about and understand the potential hazards present in their laboratories and act in a way to minimize the risk posed by those hazards.
e. Not indulge in any activity that, in their own assessment, can pose a threat either to themselves or to others in the Institute premises. In this, they are allowed to override directions given by the PI.
f. Inform the Department Safety Champion of any coercion to violate safety norms. These reports will be kept confidential. In extreme cases, information may need to be provided to the OLSEH or Safety Committee.
g. Strictly adhere to the safety practices and standard operating procedures established for the laboratories they work in. All Users are expected to be trained and tested in these practices and procedures before starting work in the laboratory to which they are assigned, and must undergo retraining and testing at regular intervals. Serious violations might lead to the exclusion of the Users from the laboratory for a specified period or indefinitely.

7. Consequences of Non-compliance and Indemnity

Any violation of this Safety Policy or Safety Rules will be handled as follows:

a. For a first-time violation, OLSEH will send a white notice to the responsible Principal Investigator, with a time frame for remedial action based on the severity of the violation.
b. If the violation is not remedied within the timeframe, OLSEH will send a yellow notice to the responsible Principal Investigator with an insistence on immediate action.
c. In case of non-compliance, even after the issuing of a yellow notice, OLSEH will send a red notice to the offending Principal Investigator and order a temporary closure of the laboratory/facility until the violation is remedied.
d. In cases of severe violations requiring immediate remedial action, the OLSEH office may directly issue a yellow or red notice.
e. In the event of damage to property or other loss caused to the Institute due to the violation of the Safety Policy or Safety Rules, the User/s shall fully indemnify the Institute and hold the Institute harmless against all loss, injury and damage. In addition, the Institute reserves the right to claim damages/compensation for any loss caused by the actions/omissions of the User in relation to the Institute's Safety Policy or Safety Rules.

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8. Acknowledgement

The lack of attention to sound safety practices can lead to the loss of property, the compromising of years of pains-taking research, serious injury, and, in extreme cases, the loss of life. The Institute, therefore, considers it the duty of all individuals to adhere to this Safety Policy and the attendant Safety Rules published on the OLSEH website.

All faculty, staff, and registered students of the Institute are expected to read and understand this Safety Policy and agree to work towards adopting a strong culture of safety.

Visitors, short-term and long-term users (such as foreign exchange students), visiting faculty, collaborators, interns, employees of companies and individuals who temporarily access facilities at the Institute under any arrangement need to acknowledge the Institute's safety policy in the manner given below.

I hereby acknowledge that I have read the '*Policy on Laboratory Safety and Environmental Health*' and understand my responsibilities under this Policy.

Signature: _____

Name: _____

Department: _____

Purpose of Stay: _____

_____

Date: _____